HART-MILLER ISLAND
SOUTH CELL ENVIRONMENTAL RESTORATION

DESIGN REPORT

100 % SUBMISSION

June 14, 2002

Contract No. DACW51-97-D-0008

Prepared for: US Army Corps of Engineers
Baltimore District

By:

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Letter of Transmittal

To:	Maryland Port Administration Harbor Development 2310 Broening Highway Baltimore, Maryland 21222	S.O. No.:	22939-014-0000-00270
		Project:	Hart-Miller Island, South Cell
Attn:	Dave Bibo	Date:	June 17, 2002

We are forwarding the following: ☐ Attached ☐ Under Separate Cover ☐ Other

DWG. NO.	NO. COPIES	TITLE OR DESCRIPTION	COMMENTS
6/14/02	1	Full size 100 % drawings	
6/14/02	1	Design Report	
6/14/02	1	Sequence of Construction Schedule Bar Chart	
6/14/02	1	Set of Specifications	

THESE ARE TRANSMITTED as checked below:

☐ As requested	☐ No exception taken	☐ Revise and resubmit
For review and comment	☐ Rejected - See remarks	☐ Submit specified items
x For your information	☐ Proceed subject to corrections noted	☐ Other

GENERAL COMMENTS:

cc:

Organization

By: Michele Monde

Title: Project Manager

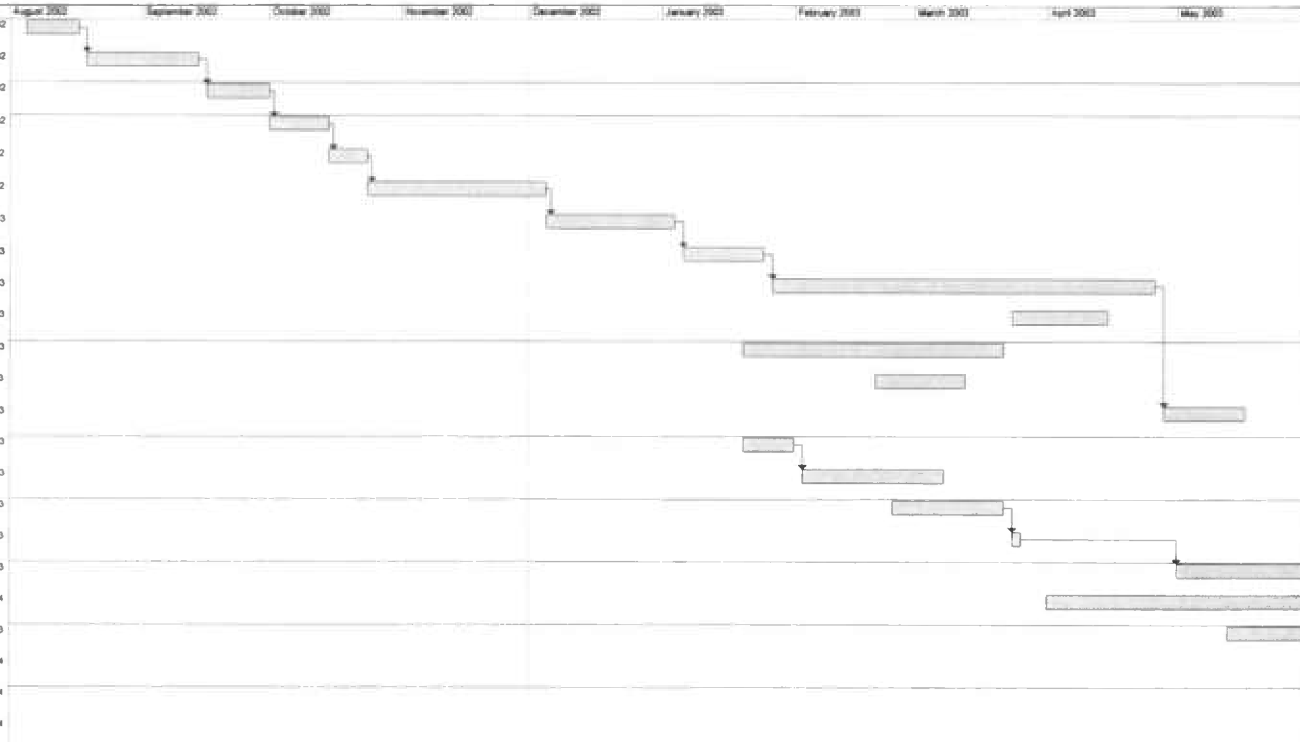
Page: 1 of 1

ChallengeUs.

Fri 6/14/02

Hart-Miller Island, South Cell
Sequence of Construction Schedule

ID	ID	Task Name	Duration	Start	Finish
1	1	Staging and Mobilization	10 days	Mon 8/5/02	Fri 8/16/02
2	2	Install Erosion and Sediment Control Measures	20 days	Mon 8/19/02	Fri 9/13/02
3	3	Clear and Grade Interior Area	11 days	Mon 9/16/02	Mon 9/30/02
4	4	Construct Nesting Island to elevation 19 feet using local material	10 days	Tue 10/1/02	Mon 10/14/02
5	5	Dewater Borrow Pit to Elevation 0.0 Feet- Discharge to Spillway #3 if permittable	7 days	Tue 10/15/02	Wed 10/23/02
6	6	Grade Borrow Pit above Elevation 0.0 Feet to final grade	30 days	Thu 10/24/02	Wed 12/4/02
7	7	Rough Grade Borrow Pit below Elevation 0.0 Feet- Grade "in wet"	22 days	Thu 12/5/02	Fri 1/3/03
8	8	Dewater Borrow Pit below elevation 0.0 feet- Discharge to Spillway #3 if permittable	15 days	Mon 1/6/03	Fri 1/24/03
9	8	Grade Borrow Pit below elevation 0.0 feet and Construct Levee	65 days	Mon 1/27/03	Fri 4/25/03
10	10	Place fill along berm in existing ditch	16 days	Mon 3/24/03	Mon 4/14/03
11	11	Install Pumping Station, Transformer and Supply Pipes	45 days	Mon 1/20/03	Fri 3/21/03
12	12	Construct Nesting Island from Elev. 19 to 22 feet using sand from borrow pit	15 days	Thu 2/20/03	Wed 3/12/03
13	13	Retrofit Spillway No 3	15 days	Mon 4/28/03	Fri 5/16/03
14	14	Construct Temporary Cofferdam at Proposed Pond Outfall	10 days	Mon 1/20/03	Fri 1/31/03
15	15	Construct Bay Connection Pipe System	25 days	Mon 2/3/03	Fri 3/7/03
16	16	Construct Pedestrian Path	20 days	Mon 2/24/03	Fri 3/21/03
17	17	Remove Temporary Cofferdam	2 days	Mon 3/24/03	Tue 3/25/03
18	18	Plant Wetland Area (Pond must be connected to Bay)	22 days	Thu 5/1/03	Fri 5/30/03
19	19	Flood South Cell to elevation 19.5 feet to determine boundaries of uplands**	266 days	Tue 4/1/03	Tue 4/6/04
20	20	Seeding (warm season grasses cannot be planted earlier)	35 days	Tue 5/13/03	Mon 6/30/03
21	21	Plant Shrubs (number of plants will require contract growing)***	130 days	Mon 10/6/03	Fri 4/2/04
22	22	Remove E/S Control Measures	11 days	Mon 4/5/04	Mon 4/19/04
23	23	Demobilization	15 days	Tue 4/20/04	Mon 5/10/04



MES tasks are shown in red. Duration of tasks may vary depending on quantity of cut/fill, availablity of equipment,etc.

Dates shown are dependent on bid process.

**Keep site flooded for a year to help with Phragmites control and soil conditioning

*** Contract growing required due to large amount of plants needed

Fri 8/14/02

Hart-Miller Island, South Cell
Sequence of Construction Schedule

ID	ID	Task Name
1	1	Staging and Mobilization
2	2	Install Erosion and Sediment Control Measures
3	3	Clear and Grade Interior Area
4	4	Construct Nesting Island to elevation 19 feet using local material
5	5	Dewater Borrow Pit to Elevation 0.0 Feet- Discharge to Spillway #3 if permittable
6	6	Grade Borrow Pit above Elevation 0.0 Feet to final grade
7	7	Rough Grade Borrow Pit below Elevation 0.0 Feet- Grade "in wet"
8	8	Dewater Borrow Pit below elevation 0.0 feet- Discharge to Spillway #3 if permittable
9	9	Grade Borrow Pit below elevation 0.0 feet and Construct Levee
10	10	Place fill along berm in existing ditch
11	11	Install Pumping Station, Transformer, and Supply Pipes
12	12	Construct Nesting Island from Elev. 19 to 22 feet using sand from borrow pit
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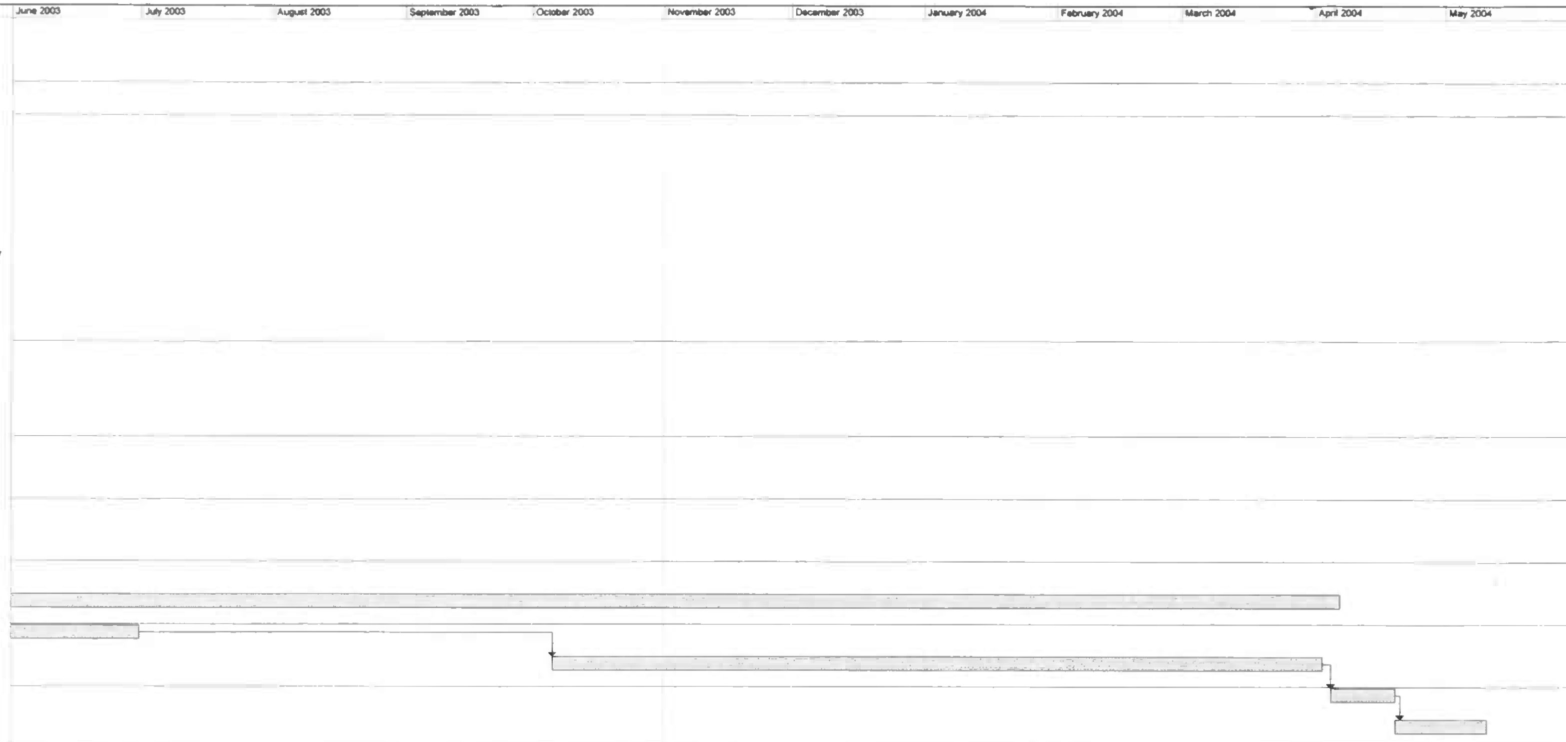
14	14	Construct Temporary Cofferdam at Proposed Pond Outfall
15	15	Construct Bay Connection Pipe System
16	16	Construct Pedestrian Path
17	17	Remove Temporary Cofferdam
18	18	Plant Wetland Area (Pond must be connected to Bay)
19	19	Flood South Cell to elevation 19.5 feet to determine boundaries of uplands**
20	20	Seeding (warm season grasses cannot be planted earlier)
21	21	Plant Shrubs (number of plants will require contract growing)***
22	22	Remove E/S Control Measures
23	23	Demobilization



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Hart-Miller Island
South Cell Restoration
Design Report- 100% Submission

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Specifications and MCASES Cost Estimate are provided as separate documents.

Hart-Miller Island
South Cell Restoration
Design Report- 100% Submission

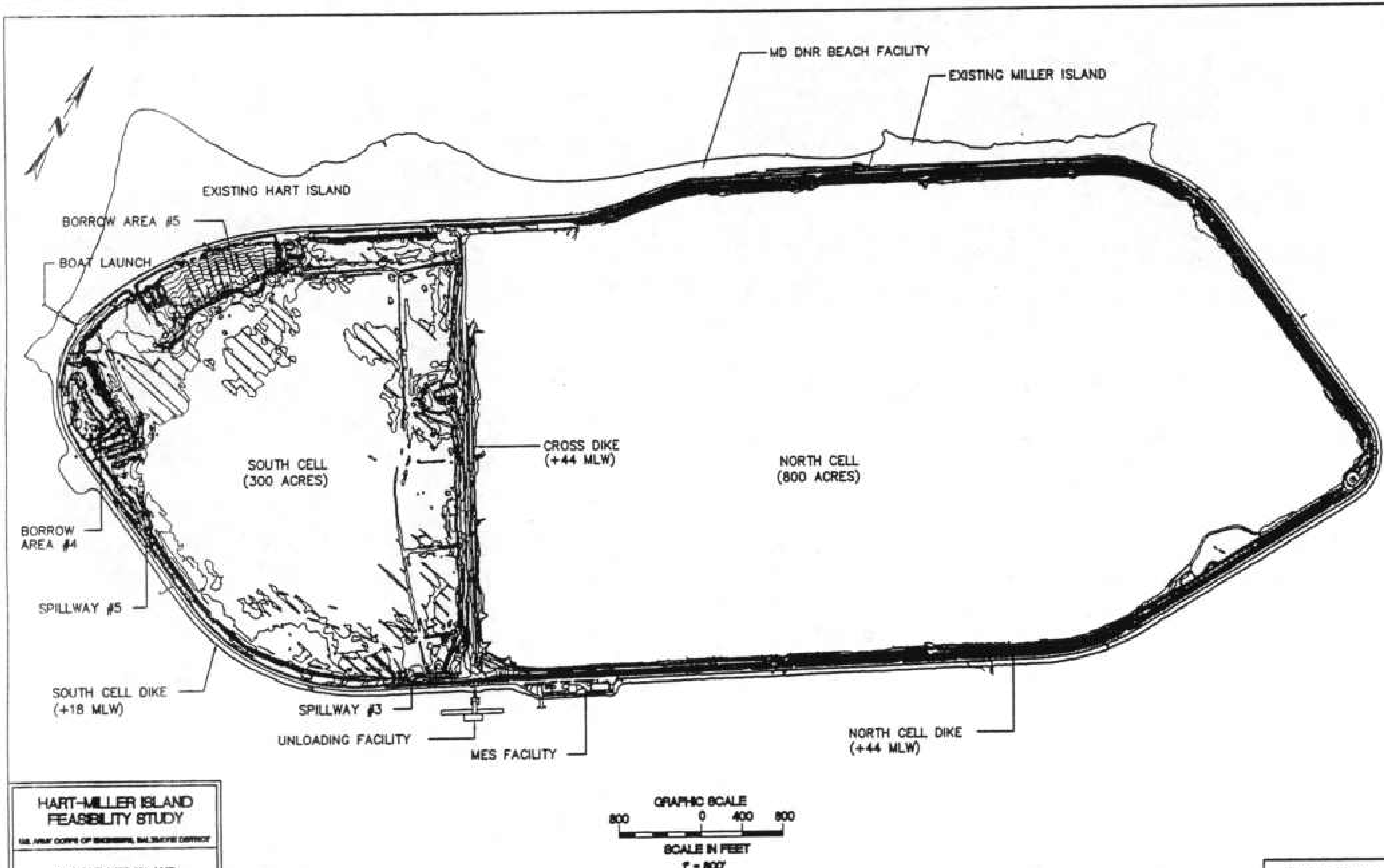
1.0 Introduction

Hart-Miller Island (HMI) is a 1,100-acre dredged material containment facility located in the upper Chesapeake Bay. The island was created by connecting the existing Hart and Miller Islands with a section of sandy beach and by constructing a perimeter dike to form the exterior of the containment facility. The facility is divided into two parcels, an 800-acre North Cell and a 300-acre South Cell (Figure 1-1).

Since 1984, HMI has been the authorized placement site for dredged material from the Baltimore Harbor and Channels Federation Navigation Project and other channel reaches serving the Port of Baltimore. Sixty-two million cubic yards of dredged material were placed into the facility by the end of 1997. In October 1990, dredged material inflows to the South Cell ceased in accordance with the Maryland State Wetlands License for this section of the facility.

In 1992 efforts to study restoration options for the South Cell began under the authority of the Planning Assistance to States Program (Section 22 of the WEDA 1974). The US Army Corps Baltimore District (Baltimore District) requested the Corps of Engineers Waterways Experiment Station to evaluate existing data and work with the State of Maryland and three local committees (the Citizens Advisory Committee, the Governor's Technical Advisory Committee, and the Technical Review Committee) to develop design concepts for restoring the South Cell.

In 1997, a Section 1135 Ecosystem Restoration Study and Environmental Assessment was begun to determine the environmental, engineering, and economic feasibility of modifying and restoring the existing South Cell for wildlife habitat and to identify a non-Federal sponsor who will share the cost of implementing the restoration project and will maintain the completed project. To meet these goals, a study team was formed which included Baltimore District, Michael Baker Jr. Inc. (BAKER), Maryland Department of Natural Resources (DNR), Maryland Port Administration (MPA), Maryland Environmental Services (MES), Hart-Miller Island Citizens Advisory Committee, Maryland Ornithological Society, US Fish and Wildlife Service, Maryland Department of the Agriculture, Maryland Department of the Environment (MDE), Maryland Geological Society, Chesapeake Bay Critical Area Commission, and Baltimore County Department of the Environment. In 1999, the final Section 1135 Ecosystem Restoration Report and Environmental Assessment report was published.



HART-MILLER ISLAND
FEASIBILITY STUDY

HART MILLER ISLAND
SITE MAP

FIGURE 1-1

1.1 Project Design

The Section 1135 study determined that the materials in the South Cell could be used to create wetlands and shallow water habitat that is rapidly disappearing in the Upper Chesapeake Bay. The habitat will serve as a habitat area for migratory shorebirds, nesting Terns, and migratory shorebirds.

The 35% level design plans and report were prepared and submitted to the Baltimore District in November 2001. Key features of that design were:

- The pond (formerly know as the "borrow pit")- The pond was the source of water for the water distribution system with a direct culvert connection to the Chesapeake Bay.
- Grading- Grading within the interior of the South Cell was minimized; it was limited to the pond and around the perimeter of the cell.
- Water elevations- Water elevations within the interior of the Cell would fluctuate between 17 feet Mean Low Lower Water (MLLW) to 20 feet MLLW, depending on the seasonal cycle.
- Water distribution system- The system would have two parts: 1) water would flow from the pond to Spillway #3 to allow the site to be flooded from the "bottom to the top" and 2) a mudflat hydration system would be installed at the top near the edge of the mudflats to allow water to flow from the "top to the bottom" of the cell.
- Pumping system- The pumping station would be automatically controlled using a supervisory control and data acquisition (SCADA) system.
- Landscaping- Landscaping would include a forested area around the pond; tidal wetlands in the pond; and upland areas around the mudflats. Wetland plants would not be planted within the interior of the cell. In the mudflats areas, development of wetland plants would be dependent on natural recruitment of plants.
- Nesting Island- A ½ acre nesting island would be placed within the interior of the cell.
- Pedestrian walkway/trail- The trail would be constructed from the current MES personnel dock to the pond and loop around the perimeter of the pond.
- Spillway #3- The spillway would be retrofitted to allow for easier manual changes to the water level and maintenance of the structure.
- Earthen berm- The earthen berm would be constructed from Spillway #3 to approximately 200 feet south of the MES personnel pier. The berm would prevent water from ponding adjacent to the exterior road along the perimeter of the island.

A Value Engineering (VE) study was conducted for this project. The recommendations from the study were presented in the report entitled "Value Engineering Study Report, Hart-Miller Island, South Cell Environmental Restoration, Maryland," prepared by the

Baltimore District and Project Management Services, Inc., and dated December 5, 2001. As a result of the VE process and comments received during the 35% review process, the design was revised. The design changes made allowed for a decrease in estimated construction costs without a significant change in the amount of created habitat. The following changes were made and were reflected in the 95% design:

- Water elevations- Water elevations within the interior of the Cell would fluctuate between 17.5 feet MLLW to 19 feet MLLW, depending on the seasonal cycle. This reduction in the range of water surface elevations resulted in less water required for the system and a reduction in pumping requirements.

- SCADA- The SCADA system was eliminated. An alarm system for pump malfunction was included in the design.

- Water Distribution Discharge Point- The discharge point for the primary water distribution system was moved from near Spillway #3 to a point located approximately 3500 feet upstream of the Spillway. By moving the discharge point, the length of pipe was reduced which resulted in a cost reduction.

- The interior berm was extended from Spillway #3 to approximately 4,900 feet upstream at the pond.

- Bay connection culvert- The bay connection culvert was moved from along the interior of the roadway to the bay side of the roadway. By relocating the culvert, excavation costs were reduced.

- Intake Filter Tee at pump station- The system was changed to eliminate one intake filter tee.

Based on comments received during the 95% review, the following changes were made to the design:

- The existing ditch located between the proposed berm and dike road will be filled to elevation 10.5 feet to increase slope stability of the berm. Additional excavation of the east side of the pond was required to obtain sufficient fill material.

- The material for the pedestrian trail was changed from asphalt to plastic grid pavers due to constructability issues associated with transporting asphalt to the island.

- The pH target level for the soil amendments was raised from 5.5 to 6.0 to help meet water quality standards.

2.0 Water Budget and Habitat Creation

2.1 Habitat Creation by Water Management

In order to create the required mudflat habitat, the water level in the South Cell of HMI will need to be actively managed. A seasonal cycle of alternately flooding and draining the site will be followed throughout the year to maximize mudflat habitat during the spring and fall migratory periods for shorebirds. A typical seasonal cycle would follow this cycle:

Month	Function	Elevation (feet-MLLW)
Jan-Feb	Full pool to provide wintering habitat for ducks	19.0
March-May	Draw down to expose mudflats for spring migration	19 to 17.5
June	Flood site to re-hydrate mudflats	17.5 to 20
July	Full pool to provide summer habitat for waterfowl	19.0
Aug-Sept.	Draw down to expose mudflats for fall migration	19-17.5
Oct- Nov.	Flood to prepare for winter full pool	17.5 to 19

Draw downs will be conducted over the duration of the drawdown period, in order to expose new mudflat habitat throughout the migration season. Draw downs are ideally done in 3-6 inch increments per week.

2.2 Water Budget for Direct Pump System

The water management cycle is critical to the creation of optimal shorebird habitat. In order to determine the water demand and pumping requirements based on the water management cycle, a water budget was developed for the project.

The water budget determines the amount of pumping that will be required to manage the water levels as described above. For each month of the year, the average acreage of mudflat and wetland (standing water area) was determined. Based on the acreage and the weekly water elevation change, a total volume of water change was determined. Pumping required for the water level management was determined by calculating the pumping volume required to flood the site, then adding inputs and subtracting outputs to determine the water balance. The components of the budget include:

Inputs

Monthly Precipitation - For a worse case scenario, monthly rainfall data from a dry year was used.

Outputs

Monthly Evapotransporation-Water loss due to evaporation and transpiration by plants

Monthly Infiltration- Water loss through infiltration through the bottom of the site

Pumping Requirements- The resulting balance in acre-inches was converted to a gallon per minute (gpm) pumping rate

2.3 Water Budget for Mudflat Hydration System

The water budget also includes calculation of pumping requirements for a mudflat hydration system ("dribble" system) to keep the exposed mudflats in a hydrated state during draw down. This pumping would be in addition to the major water level changes previously calculated for the direct pumping system. For each month, the evaporation and infiltration rates for the exposed mudflats determined the water loss from the mudflats. It was assumed that four inches of additional water per month in excess of losses would be required to produce sheet flow across the site. The input of direct precipitation to the mudflats was then subtracted from the total water demand to determine the amount of pumped water required from the Mudflat Hydration System as shown in Table 2.1.

2.4 Summary of Water Budget

Table 2.2 provides a summary of the pumping requirements needed for the water budget. The water budget provides an estimate of the pumping volumes and rates upon which to base the sizing and configuration of a pumping system.

Direct Pump System

- Pumping would be required during flooding periods (June, Oct. and November)
- Pumping would be required to compensate for evaporation during July
- Direct pump system would operate for only 4 months of the year
- Pump rates assume 24 hours/7 days operation
- Pumping rates ranges from 542 to 2,366 gpm

Mudflat Hydration System

- System would operate whenever there are exposed mudflats
- System would operate for 7 months of the year
- Pump rates assume 24 hours/7 days operation
- Pumping rates range from 16 to 523 gpm

Table 2-1 Wetlands Water Management Budget

Wetland Water Management
Hydration System for Mudflats with Direct Pumping for Pool
Using Dry Year Data

Assuming Maximum Mudflat Acreage = 149

		Elevation			Ponded Area			Mudflat		
	Water	Start	Ending	Change	Start	End	Average	Start	End	Average
Month	Management	Feet MSL	Feet MSL	In/week	Acres	Acres	Acres	Acres	Acres	Acres
Jan	Full Pool	19.0	19.0	0	149	149	149	0	0	0
Feb	Full Pool	19.0	19.0	0	149	149	149	0	0	0
Mar	Full Pool	19.0	19.0	0	149	149	149	0	0	0
April	Drawdown	19.0	18.0	-3	149	71	110	0	78	39
May	Drawdown	18.0	17.5	-1.5	71	29	50	78	120	99
June	Flood	17.5	19.0	4.5	29	149	89	120	0	60
July	Full Pool	19.0	19.0	0	149	149	149	0	0	0
Aug	Drawdown	19.0	18.0	-3	149	71	110	0	78	39
Sept	Drawdown	18.0	17.5	-1.5	71	29	50	78	120	99
Oct	Flood	17.5	19.0	4.5	29	149	89	120	0	60
Nov	Full Pool	19.0	19.0	0	149	149	149	0	0	0
Dec	Full Pool	19.0	19.0	0	149	149	149	0	0	0

	Pumping for Water Level Management								Pumping Requirements	
	Pumped Volume for Water Management	Precipitation		Evapotransporation		Infiltration		Total Pumped Volume	Volume	Pump Rate
Month	Acre/In	Inches	Acre/In	Inches	Acre/In	Inches	Acre/In	Acre/In	Gallons	GPMinute
Jan	0.00	2.9	432	0.2	30	0.36	54	-349	0	0
Feb	0.00	2.8	417	0.2	30	0.36	54	-334	0	0
Mar	0.00	3.9	581	1	149	0.36	54	-378	0	0
April	-1320.00	1.8	198	2	220	0.36	40	-1258	0	0
May	-300.00	2.8	140	3.9	195	0.36	18	-227	0	0
June	1602.00	1.9	169	5.8	516	0.36	32	1981	53,792,706	1,245
July	0.00	2	298	6.4	954	0.36	54	709	19,257,568	446
Aug	-1320.00	5	550	5.8	638	0.36	40	-1192	0	0
Sept	-300.00	1.8	90	4	200	0.36	18	-172	0	0
Oct	1602.00	1.7	151	2.1	187	0.36	32	1670	45,334,733	1,049
Nov	0.00	0.9	134	1	149	0.36	54	69	1,861,025	43
Dec	0.00	0.8	119	0.25	37	0.36	54	-28	0	0

	Pumping for Hydration System								Pumping Requirements		
	Mudflats (sheetflow)		Evapotransporation From Mudflats		Infiltration from Mudflats		Precipitation Over Mudflats		Total Pumped Volume	Volume	Pump Rate
Month	Acres	Acre/In	Inches	Acre/In	Inches	Acre/In	Inches	Acre/In	Acre/In	Gallons	GPMinute
Jan	0.00	0	0.2	0	0.36	0	2.9	0	0	0	0
Feb	0.00	0	0.2	0	0.36	0	2.8	0	0	0	0
Mar	0.00	0	1	0	0.36	0	3.9	0	0	0	0
April	39.00	156	2	78	0.36	14	1.8	70	178	4,828,783	112
May	99.00	396	3.9	386	0.36	36	2.8	277	541	14,676,958	340
June	60.00	240	5.8	348	0.36	22	1.9	114	496	13,456,729	311
July	0.00	0	6.4	0	0.36	0	2	0	0	0	0
Aug	39.00	156	5.8	226	0.36	14	5	195	201	5,464,149	126
Sept	99.00	396	4	396	0.36	36	1.8	178	649	17,633,855	408
Oct	60.00	240	2.1	126	0.36	22	1.7	102	286	7,754,725	180
Nov	0.00	0	1	0	0.36	0	0.9	0	0	0	0
Dec	0.00	0	0.25	0	0.36	0	0.8	0	0	0	

Elevation/Acreage Table

Elevation	Open Water Acreage	Mudflat Acreage
17.5	29	120
18	71	78
18.5	102	47
19	149	0

NOTES:
- Negative pumped volume indicates drawdown, no pumping for water management.
- Negative total pumped volume indicates discharge from spillway 3
- Hydration System includes hydration by precipitation
- Not including precipitation would increase pumping requirements.
- Sheet flow across mudflats assumes that 4 inches of water is required during the month
- Actual spring draw down would start mid-April and early June (6 weeks)
- Actual Fall Draw down would start mid-August and end late September.

Table 2-2 Summary of Pumping Requirements

Hart-Miller Island
Summary of Pump Requirements
Revision Based on VE Study

	Direct Pump Plus Hydration System		
	Water Level Control	Hydration	Total
	GPM	*GPM*	*GPM*
Jan	0	0	0
Feb	0	0	0
Mar	0	0	0
April	0	112	112
May	0	340	340
June	1,245	311	1,557
July	446	0	446
Aug	0	126	126
Sept	0	408	408
Oct	1,049	180	1,229
Nov	43	0	43
Dec	0	0	0

Comments

Hydration System with Direct Pump
Direct pumping required in flood periods (June, Oct.)
Direct pumping required in July to compensate for high evaporation rates
Hydration System operating whenever there is exposed mudflats
Direct pump system operates for only 4 months per year
Hydration system requires operation for 6 months
Hydration system volumes assumes 24/7 operation during each month
If hydration system is operated only at night, then higher pumping rates per hour are required

3.0 Estimate of Tidal Datums

Tidal datum characteristics for four (4) NOAA tidal stations closest to Hart-Miller Island are presented in Table 3-1. Hart-Miller Island is located approximately at 39 degrees 15.0'N and 76 degrees 22.5'W. The table presents Mean Higher High Water (MHHW); Mean High Water (MHW); Mean Tide Level (MTL); Mean Low Water (MLW); and Mean Lower Low Water (MLLW) related to MLLW. Other adjacent stations, such as Fort McHenry, Curtis Creek, and Pond Point (Aberdeen Proving Ground) were reviewed and judged to be in locations where estuarine effects bias the reported datums. It can be seen that the tide range is slightly greater at the Hawkins Point Station, which is halfway up the Patapsco River toward Baltimore and may be slightly amplified by the necking down of the river. Cornfield Creek is slightly south and inside the Magothy River. Stony Creek and North Point are closest to Hart Miller and probably most indicative of tide conditions there. Local information from a construction drawing at Hart Miller Island reports that MHW is 1.1 feet above MLW, thereby providing some verification of these estimates.

As a preliminary approximation for tidal elevations at Hart-Miller Island, it is recommended that the average of all four (4) stations shown in Table 3-1 be used, as shown in Table 3-2. Coincidently, the average of all four stations shown in Table 3-1 agree to within 0.1 feet with the average of the two closest stations. The Hart-Miller tidal elevation statistics should have an uncertainty of about plus or minus 0.1 feet due to the variation of tide statistics in the area. Tide measurements at the site or numerical modeling of the bay surrounding the island would be required to refine the astronomical tidal characteristics. This was not part of the scope of work for this design.

Table 3-1 NOAA Tide Statistics, feet MLLW

Tide Elevation	Hawkins Point, MD 39°12.5' N 76°31.9' W	Stony Creek, MD 39° 9.8' N 76° 31.6' W	North Point, MD 39° 11.9' N 76° 26.8' W	Cornfield Creek, MD 39° 6.0' N 76° 26.8' W
MHHW	1.72	1.58	1.58	1.49
MHW	1.39	1.28	1.27	1.20
MTL	0.81	0.75	0.75	0.71
MLW	0.23	0.23	0.24	0.23
MLLW	0.0	0.0	0.0	0.0

Table 3-2 Estimated Astronomical Tidal Characteristics, Hart Miller Island, MD

DATUM	ELEVATION (Feet MLLW)
Mean Higher High Water (MHHW)	1.58
Mean High Water (MHW)	1.28
Mean Tide Level (MTL)	0.75
Mean Low Water (MLW)	0.23
Mean Lower Low Water (MLLW)	0.0

4.0 Geotechnical Data

As part of the design process, 19 borings were taken at selected locations in the South Cell (See Design Sheets C1-C4). The borings were taken by the Baltimore District using a CME45 drill rig and 3 ¼" Hollow Stem Auger. A geotechnical inspector was onsite during all the drilling. Standard sampling procedure was to collect samples by the SPT Method. In the SPT Method, a 1 3/8" split spoon is beaten down 18 inches by a 140-lb hammer dropped 30 inches per blow. The preliminary boring logs were revised as necessary based on the information available from the gradation and Atterberg Limit tests. The final boring logs are included in Appendix A and are shown on Design Sheets C16-C19. The geotechnical analysis and calculations are contained in Appendix A.

Because of the potential for Unexploded Ordnances (UXOs) in the dredged material in the South Cell, a MK26 magnetometer was dropped into each hole prior to drilling for each to check for the presence of UXOs. The UXO work was conducted by Human Factors Associates under separate contract to Baltimore District. No UXOs were uncovered during this investigation.

As part of the feasibility study in 1998, borings were also taken in the South Cell. The boring logs for this testing period are shown on Design Sheets C20–C22 and are also included in Appendix A.

5.0 Site Work

5.1 Site Preparation

Prior to the start of construction, the area designated to be mudflats and upland areas (forested, shrubs and upland grasses) will be treated for invasive species. This will encompass approximately 176.6 acres of mudflats and 126.8 acres of upland areas. Refer to Specification 02930, Exterior Planting. After initial control of invasive species, the site will be mowed no more than 4 inches above the ground. Cut material will be left on site.

5.2 Site Grading

The majority of the interior of the South Cell where the wetland/mudflat habitat will be located will not be graded. Minor grading will be done in one area of the cell to maximize the 19 foot pooled area. Table 5-1 provides a summary of the estimated cut/fill quantities.

To isolate and maintain the proposed wetland/mudflat habitat, a perimeter berm will be constructed along the existing perimeter channel system. The berm will extend from Spillway #3 to the area of the pond located on the north side of the South Cell. The berm will be graded to a minimum elevation of 22 feet MLLW. At this elevation, the berm will be higher than the elevation of the 100- year storm event at the required full pool of 19 feet MLLW. A HEC-1 hydrologic analysis for the 100-year storm event was performed to determine the 100-year flood event and to verify that Spillway 3 has sufficient capacity to pass this flood event. The HEC-1 analysis is included in Appendix B.

During construction, the berm will be constructed to elevation 23.0 feet MLLW to account for any potential settlement. The berm will be designed with a minimum 10-foot width and tie back into the existing cell at maximum 10:1 slopes to maintain stability and minimize risk of failure at the channel side. The existing channel side slopes will be maintained at a maximum 4:1.

The existing ditch which runs parallel to the inside of the perimeter dike road will be filled to an elevation of 10.5 feet MLLW to increase the stability of the berm. The fill be placed from Station 0+00 to Station 24+90. The fill for this will be taken from excavation in the pond.

The proposed pond and bay connection system will be graded to a minimum elevation of – 3 feet MLLW to provided adequate depth to maintain tidal flow into the system. The pond will be graded to lower depths (-8 feet MLLW) at the location of the proposed intake pipe as required. The pond will be graded to provide a shallow shelf for the planting and development of tidal wetlands. The side slopes along the pond and existing channel will be maintained at 4:1 to minimize slope failure. Slope stabilization measures will be provided in areas where 4:1 slopes cannot be established.

5.3 Bay Culvert

To provide a constant water source for the habitat system, a permanent connection between the Chesapeake Bay and the proposed pond will be established. A headwall and approximately 1200 linear feet of 36" High Density Polyethylene (HDPE) pipe will be constructed beginning at a location near the existing MES HMI dock. The invert of the pipe will be set at an approximate minimum elevation of –3 feet MLLW in order to maintain full capacity at low tide. The pipe will breach the existing perimeter road and outflow into a constructed channel system to the proposed pond. The channel and pond will be graded to sufficient depths to maintain circulation. To minimize potential environmental impact, the outflow end of the culvert will be fitted with a duck bill tide valve to prevent backflow into the Bay. The valve can be removed if further study shows the impact to the existing Bay system is negligible, thereby providing actual tidal flow through the system.

5.4 Spillway #3 Retrofit

The existing spillway was constructed in 1981 to control the water surface in the South Cell disposal site. It consists of three cells connected to separate outfall pipes and controlled by manually operated sluice gates. Water levels are controlled by a weir system of wooden boards placed within steel guide rails in front of the gates. Spillway #3 also functioned as a discharge point for water from the North Cell. Water was directed from the North Cell to the South Cell through several pipes that crossed the cross dike. The spillway is presently inactive due to the discontinued use of the South Cell and the fact that water in the North Cell now discharges through another spillway in the North Cell, located east of Spillway #3. Information on Spillway #3 was obtained from the as-built plans dated March 1981 and from discussions with maintenance personnel on the island.

In the South Cell Restoration Design, Spillway #3 will control the water surface in the mudflat/wetland areas. Weir boards will be used at the spillway to control the water surface elevations from elevation 17.5 to 19.0 feet MLLW. To meet the design requirements, retrofits to Spillway #3 are required. These include the following:

1. Installation of three (3) slide gates, connected to handwheels located at the uppermost deck. Taking into consideration the marine environment of the existing spillway, a slide gate with corrosion-resistant components was chosen.
2. Additional timber baffles might be needed to complete the retrofitted spillway, so it will function as intended (i.e., to be able to raise and lower water surface elevations, as desired). Existing timber baffles, which are still in good condition, shall be re-used, as per concurrence of the contracting officer.
3. A new ladder and an opening shall be installed so that maintenance work might be performed within the enclosed chamber.

All existing and new steel members of the spillway structure are to be sandblasted and coated with dielectric coating from top of structure (elevation 32 feet MLLW) to 6 inches below the existing mudline or to an elevation of 11.5 feet MLLW, whichever is deeper. Excavate steel columns to the above-required elevation prior to sandblasting and coating of the columns. A cathodic protection system consisting of aluminum galvanic anodes should be installed on the submerged portion of the spillway structure to provide corrosion protection to the steel members. After the completion of the installation of the cathodic protection system, and once the water level of the mudflat area has reached its expected level, testing should be performed to insure that the cathodic protection system is providing an adequate level of corrosion protection to the submerged steel members of the spillway structure.

See Appendix C for foundation analysis for the spillway.

5.5 Pedestrian Walkway

A pedestrian walkway constructed of plastic grid pavers was designed to provide access from the boat launch to the pond area. The original design called for the walkway to be asphalt pavement or asphalt tar and chip. However, further investigation on construction of the asphalt walkway on the island and the durability of the tar and chip pavement showed that these were not viable options for this site. Therefore the plastic grid pavers were selected.

The walkway begins on the interior side of the perimeter road across from the MES personnel dock. It continues to the pond and loops around the perimeter of the pond back to the walkway along the road. The walkway was designed to meet the requirements of the American Disability Act as much as possible. The walkway will be eight feet wide and have a maximum slope of five percent. Some minor grading work will be required in one area on the south end of the pond and one area on the north end. A 24" CMP culvert crosses the path the north end of the pond.

5.6 Nesting Island

One component of the design plan is a nesting island for the Least Tern, a Federally listed threatened species. This species requires relatively undisturbed and predator free habitat in order to reproduce successfully. This species nests on the ground, preferably on sand or shell/pebble substrate with less than 15% vegetation cover.

To provide breeding habitat in South Cell of Hart Miller Island, a small (0.5 acres) nesting island will be created within the mudflat habitat area. The island will be located centrally within the mudflats, approximately 300 feet from the nearest uplands, in order to reduce human disturbance and predation by fox, raccoon, and other mammals.

The elevation of the island will be at 22 feet MLLW. From elevation 17.5 feet MLLW to 20 feet MLLW, the island can be constructed with suitable compacted backfill. From elevation 20 to 22 feet the island should be constructed of sandy fill. A mixture of sand and shells (nesting substrate) will be placed from elevation of 22 to 23 feet. The island will be constructed to elevation 23 feet MLLW to account for potential settlement. Erosion protection material will be placed around the perimeter of the island. No vegetation will be planted on the island.

Some maintenance may be required to keep optimal habitat conditions on the island. Over time vegetation may become established and course nesting substrate may become covered by finer sediment. Periodic removal of vegetation and possibly redistribution of the nesting substrate will maintain the optimal nesting conditions on the island.

Table 5-1 Hart-Miller Island
Cut/Fill Quantities
100 % Design

Location	Cut Volume (Ft^3)	Fill Volume (Ft^3)	Total
Scrape-Off Area (see sheet C-03)	-127,655		
Berm		+280,516	
Pond	-831,545		
Nesting Island		+230,655	
East Bank of Pond	-163,435		
Ravine along berm		+542,548	
TOTALS	**-1,122,635**	**+1,053,719**	**-68,916**

TOTAL EXCESS CUT VOLUME IS 68,916 CUBIC FEET (2,552 CUBIC YARDS)

Excavation for culvert 63,525 cubic feet excavation and backfill

6.0 Pumping and Water Distribution System

6.1 Introduction

This is the design section for the Pumping and Water Distribution System at the Hart Miller Island South Cell Restoration Project. The purpose of this section is to describe the intent of the design engineer, to outline the alternatives analyzed for components of the system, and to provide detailed design calculations for the components selected for construction. This report should be of assistance to all reviewers of the project, be they Quality Assurance Review, Peer Review, Value Engineering Review, or Design Review.

6.2 Pumping and Water Distribution System Description

The water distribution system for the Hart Miller Island project will contain multiple components. Starting at the hydraulically high side, there will be a conduit connecting the Chesapeake Bay to the former borrow pit (hence forth described as "the pond"). The connection will be in only one direction. In the pond, there will be an intake screen and pipe leading to a wetwell at a pump station adjacent to the pond. The pump station will primarily pump Bay water via forcemain to an outlet point near the southwest portion of the mudflat. In addition, the pump station can pump Bay water to a force main network located at the high side of the mudflats that will sprinkle water along its length (also described as the "Mudflat Hydration System"). Spillway #3 will be the primary outlet pond from the South Cell back to the Chesapeake Bay.

Water Budget Requirements

The details of the development of the water budget requirements are included in Section 2.0 of this report. That water budget reflects changes made to the water budget after the December 2001 VE analysis. As part of the VE analysis, it was recommended that the mudflat area only be filled to +19.0 ft MLLW rather than the previous +20.0 MLLW. The water budget provides average flow rates by month to achieve two primary purposes: for water level control of the wetlands, and to keep exposed mudflats hydrated. The average flow rates to achieve these goals vary considerably from month to month. To engineer the pumping system components, it is not necessary to mimic the variable flow rates, but rather to set the pump controls at discreet pumping levels, to be turned on and off as necessary. In short, the pumping system is not designed to be continuous and variable flows, but discreet flow rates at variable times.

To meet this goal, two separate pumps are to be provided. One pump will service the mudflat hydration system, and one pump will service the water level control flooding. Previous designs included four equal pumps that were capable of pumping to both systems. The switch was made to two dedicated pumps due to the precise flow requirements of the agricultural sprinkler heads in order to maintain proper water dispersal to create sheet flow. Without a dedicated pump, it would be impossible for the mudflat hydration sprinklers to be properly sized and spaced without an exact and consistent flow to the sprinkler heads. This was not possible under the previous four-pump design. The flow to the mudflat hydration system is based on the design parameters of the sprinkler heads themselves, rather than the water budget. To maintain the proper water budget, the mudflat hydration system will be operational for a certain period of time until the water budget has been met, and then will shut down until the following day. The target flow rates for design are:

- 0 gpm — all pumping off
- 1245 gpm — pumping for water level control flooding
- 1332 gpm — pumping to the mudflat hydration system (maximum required by water budget is 408 gpm if run 24/7, but it is planned to only run for a few hours at night to hydrate)
- 2577 gpm — pumping for both water level control flooding and for mudflat hydration

6.2.1 Pumping Intake System

General Description

The intake system will be drawing water from the existing borrow pit pond, which is to be regraded and revegetated per the overall requirements of the project. Major design considerations for the intake system include: general screen type, hydraulics, and maintenance needs. Minor considerations include: air backwash system, plan location of intake, elevation of intake, and corrosion resistance.

Intake Geometry

Location

Elevation

The top elevation of the intake screens is to be set at four feet below MLLW (Elev. –4.0). This was established utilizing several criteria. One, no nautical traffic is expected in the borrow pit pond (the pond), thus there is no need for designing for navigational hazard criteria.

The pond is hydraulically fed from the bay, from tidal influence, but a backflow flap valve is to be included thus the pond should only lose water from the pumping or evaporation. (i.e. the tide only flows in, never back out through the flap valve). The backflow flap valve serves two purposes. First, it allows a high water mark to be maintained in the borrow pit pond ensuring that there is always adequate amounts of water during pumping without having to worry about extremely low tides. Second, it prevents release of any contamination that may be present in the borrow pit pond. If monitoring becomes a necessity, the only release point for water from the system would be from Spillway 3. But to be conservative in design, it was considered that the backflow flap either was removed purposefully at some point, or damaged and would not function as intended, thus the intake screens were set at an elevation that would, only under extreme conditions, be exposed. In addition, the pump station will have shut off floats should the intake screen ever go dry. The –4.0 foot elevation was determined to be a reasonable elevation. The extra expense for this factor of safety is a slightly deeper trench for the intake pipe, and provides extra flexibility in design and future considerations for a minor cost.

Siltation Potential

In consultation with manufacturers of intake screens, it was determined that an acceptable clearance for siltation potential is about one-half the diameter of the intake screen. With the expected pond grading, there essentially is no design concern, as the pond bottom is roughly 80 feet wide, and the current intake configuration requires a roughly 10 foot wide bottom. It was determined that a two-foot diameter screen would be adequate for the required flow. The screen requires a half diameter clearance above and below to avoid siltation and clogging problems. Thus, utilizing this screen, a depth of four feet is required while the current design is for an eight-foot depth pond.

Hydraulics

Pipe Size

The horizontal intake pipe is 14". At the maximum flow rates expected (2700 gallons per minute,(gpm)), the velocity though this pipe is about 5.0 feet per second (fps). There will be a sluice gate to close the pipe and the entrance to the wet well. See Appendix D, section 6.2.1.

Pipe Slope

The intake pipe slopes upward from the intake screen to the wet well sump. The intake pipe is sloped upward to decrease the depth of the wet well sump, thus saving excavation and construction costs. The slope of the pipe is 10%.

Floatation/Anchoring System

The intake pipe and intake screens will be provided with an anchoring system to prevent floatation. Flotation calculations for the intake screen and pipes are located in Appendix D, section 6.2.1.

Screening Mechanism

Sizing and Specifications

There are two basic types of intake screens: a drum style and the Tee Screen style. In consultation with manufacturers, the Tee Screen style was recommended including a size of 24". The T screen design also allows for a type of redundancy in that there are actually two separate screens on either end of a T in case one side would get clogged. Using the nomographs, it was determined that the T screen design would be appropriate.

Maintenance of Screens

The intake screens should be checked monthly when in operation, and the screens should be brushed prior to startup in April and again at the beginning of August. This system is designed to have minimal maintenance.

Air Backwash System

As a preventive measure to avert any collection of materials or algae growth on the screens, the manufacturers recommended installation of an air backwash system. It was determined that this option was relatively non-labor intensive and was standard for this type of intake system. The system would include a 5 hp compressor attached to a 120-gallon tank with a 2-inch air line hose run from the compressor out to the intake screen backwash nozzles. The backwash would be performed every 60 minutes, and the compressor would refill the tank in 30 minutes. The compressor and tank are planned to be installed in a pre-fabricated fiberglass structure adjacent to the pump station. This structure will also house an electrical panel and controls for the pumps.

Materials and Corrosion Protection

Specific materials and/or corrosion protection systems will include a stainless steel body and backwash system piping with the screens constructed of a copper/nickel alloy. The copper/ nickel alloy screen will be utilized for the intake screen so that it will remain clean even in waters infested with Zebra mussels. The backwash piping run from the compressor to the intake screen will be 2" HDPE piping. HDPE was selected for its low cost and non-corrosive properties for this type of environment.

Maintenance Requirements

Maintenance Access to Intake Screens

There will not be an access structure to the intake screens. Monthly inspections and screen scrubbings are expected to be performed by staff from an existing boat. No special considerations were made for a launching area for the boat.

6.2.2. Pump Station

General Description

The pump station has two primary functions. The first is to pump water seasonally from the pond to flood the created wetlands, through the lake force main. The second is to pump water to the mudflat hydration system (MHS) through the MHS force main. The desire is to make the pumping system relatively low maintenance, for operation to occur automatically, and for signaling appropriate personnel not on site should there be a system malfunction.

Thus, the pumping system will be equipped to run with a relatively simple automated control. The pumps will be designed to turn on and off at set time intervals during the day. Depending on the month, the pumps will run for a set period of time per 24 hour period to meet the requirements set forth by the water budget. The control panel will also be set up to allow manual on/off pump controls, as well as retiming of the pumps if a different water budget is deemed necessary in the future.

In the case of system failure, the pump station will have a radio transmitter attached that will signal the Maryland Department of Natural Resources station on the island, which will automatically call a preset number on the mainland when the station is not occupied. System failure would include shut down of a pump during normal operation. The pump will be designed to automatically shut down due to water leaking into the housing, low water level, or clogging of the pump itself.

Structural analysis calculations for the pump station are included in Appendix C.

Selection of Pump Type

The pump station configuration has not changed greatly from the original feasibility study except in location. It will have a screened intake in the pond leading to a wet well. In the wet well there will be two stainless steel submersible pumps. The lake fill pump will have a minimum capacity of 1250 gpm against 50 feet of TDH. The MHS pump will have a minimum capacity of 1332 gpm against 210 feet of TDH. Calculations for both can be found in Appendix D, section 6.2.2. Stainless steel has been chosen as the pump material due to the corrosive nature of the bay water in which the pumps will operate. Discussions with the pump manufacturer representatives have lead to this recommendation over standard off the shelf pumps.

Sizing of Wet Well

The wet well is sized primarily by the space requirements for the pumps. Consideration was given to physical distance between the pumps for accessibility and for vortex considerations when the pumps are running. Thirty-seven inches (37") center-to-center was determined to be adequate for these considerations.

Storage capacity of the wet well is not a consideration for this pump station as the water level fluctuates only with the tide level. There is no concern that the pump capacity must match the maximum inflow rate, as in a sanitary sewage pump station. And there is not a peak inflow rate that needs to be stored, as in a storm water pump station. Regardless, a low water alarm and automatic pump shut-off will still be included to account for the possibility of a blockage in the intact pipe, or inadvertently closed sluice gate.

See Appendix C for the foundation analysis for the wet well.

Outlet Piping Configuration

The piping is designed so each pump/piping system is completely independent of the other pump/piping system. Each piping system will have a check valve included on the outlet pipe. The check valve is to protect against extreme backflow pressures in case of a pump shutdown. In addition, each outlet pipe has a gate valve, with extended hand wheel, so that each pump outlet can be segregated from the piping system for maintenance or during times when the pumps are not in operation (winter). The valves are in a vault structure for ease of access and maintenance. The lake fill pump is using a twelve-inch (12") diameter discharge pipe. The MHS pump is using a 14" diameter discharge pipe. The discharge pipes will be constructed to lie on the existing ground surface, except when required to traverse roadways, in which case they are direct burial. Aboveground installation allows lower installation costs and ease of discovery and correction of pipe failures.

Electrical

The power for the pump station and associated equipment will be derived from the existing 13.2kV primary feeder that runs across the Island. The existing feeder will be cut and rerouted through a new manhole and pad mounted 15kV sectionalizing switch. The new switch will permit the existing line to be tapped and provide the capability to isolate the pumping station from the existing DNR. A new 13.2kV cable will extend to the site of the pump station where a pad-mounted transformer will be located. This transformer will provide 480/277 volt power to a panelboard in the building. This panelboard will feed all the 480volt motor loads and a 480-120/208 volt dry type step down transformer. There will also be a 120/208 volt panelboard for receptacle, interior lighting and control circuits.

A limited amount of lighting will be provided. The interior shed lighting will consist of surface mounted fluorescent fixtures. There will be one exterior pole-mounted fixture. This fixture will use a high pressure sodium 250 watt lamp for energy savings and be controlled by a line voltage 277 volt photocell. Manual switches will control the interior shed lighting.

Enclosure Shelter

A shelter was deemed necessary to house some of the components that would be susceptible to the elements. Those components include both the compressor for the backwash system, as well as the control panels for the pumps and the relay system for the pump shutdown warning.

The selection of the shelter type was based on being able to stand up to the corrosive environment of the salty air and blowing sand found on the island. A standard fiberglass reinforced polyester (FRP) shelter was chosen.

Access Road

An access road was designed to allow maintenance crews to access the shelter and pump station from the existing perimeter road. The access road is not to be paved, as the minimal (perhaps twice monthly) amount of traffic utilizing a light truck, would handle the gravel surface without the expense of paving. In addition, the existing perimeter road is a gravel road. The access road is designed to allow the truck to be maneuvered into position to load the pumps directly into the bed of a truck for off site maintenance work.

Pump Hoist

After speaking with several manufacturers, an off-the-shelf hoist was selected. Several manufacturers make similar types of manual chain hoists capable of lifting one ton, and weighing less than 100 pounds. The hoist is designed to run on a manual trolley along an existing beam structure included in the design. The hoist is designed to lift the pumps from inside the sump, straight up and out of the enclosure, and then be pushed along on the trolley and beam to be lowered into the bed of a light truck parked on the access road.

Due to the harsh environment, a light hoist was determined to be most beneficial. The light hoist and trolley are capable of being removed from the beam structure and stored in the FRP shelter when not in use.

See Appendix C for structural analysis of the pump hoist.

Pump Station Accessories (Ladders, Sluice Gate, Access Hatches)

All of the pump station accessories were selected based on cost and their ability to require minimal maintenance to stand up to the harsh island conditions. The ladder and sluice gates were chosen to be constructed of FRP to the extent possible, with all mechanical screw type components on the sluice gate being constructed of stainless steel. The access hatches into the wet well are constructed of stainless steel.

Maintenance Requirements

Maintenance requirements for pumps, compressor, and hoists will be based on the manufacturers suggested recommendations.

6.2.3 Lake Fill and MHS Force Main

General

The major issues for consideration in designing the two force mains include hydraulics (pipe size and material), horizontal location, anchoring of aboveground pipe, depth of bury, and flexibility of the piping material in the relatively unstable material on the island.

Hydraulics

Size and Materials

Water will be pumped from a pump station located on the northwest side of the pond directly into the lake fill and MHS force mains. The lake fill force main will carry the water to be used to flood the mudflats. It will discharge at an outlet near the southwest part of the fill area. Normal operating will have this force main either running at 1250-gpm or off. Using Hazen-Williams methodologies the force main was preliminarily sized at 12-inches for 1250-gpm yielding pipe velocities of 5.0 fps. This is an acceptable flow rate for the pipe material selected. The total dynamic head (TDH) through this pipe is approximately 50 feet at the pump.

The MHS force main will run for 1384 feet from the pump station north and east around the pond to the mudflat hydration system piping. Normal operating for the MHS force main will be 1332-gpm or off. Using Hazen-Williams methodologies the MHS force main was sized at 14 inches for 1332-gpm yielding pipe velocities of 3.1 fps. The TDH through this pipe is approximately 207-feet at the pump. All of the piping calculations are included in Appendix D, section 6.2.3.

The materials for the piping will be HDPE. This material is perfectly suited to this type of environment. It does not corrode under these conditions, and the requirement to include a minimum of 2% carbon black in the HDPE mixture, allows aboveground installation with no breakdown of the material under direct sunlight exposure. The piping will be connected utilizing butt fusion joints or electrofusion couplings on HDPE to HDPE connections and a stainless steel backup ring/connecting flange when connecting to stainless steel flanged appurtenances (pump, valves, and sprinkler riser piping).

Location

Horizontal Typical for Lake Fill

Several typical alignments were analyzed for the location of the lake force main. The pump station location to the west of the pond and the discharge location, at the southwest corner of the fill area are the fixed points for reviewing potential alignments. A brief discussion of each follows.

Lake fill force main in the perimeter road or on the outside edge of the perimeter road: Per the request of MES, construction in the existing perimeter roadway was to be avoided. Alignment not used.

Lake fill force main along the inside edge of the perimeter road: Along a majority of the route, there is a steep drop into a road-side channel. Alignment in the channel is not desirable for future access, and construction along the embankment is not desirable. Use this alignment for 795 feet, from wet well to the newly graded area adjacent to the new walking path around the borrow pit pond.

Lake fill force main within new berm area: Not desirable to have pipes within a berm. Alignment not used.

Lake fill force main along inside edge of new berm: This alignment results in the lake fill force main being less accessible to the perimeter road, and more likely to be influence by the settling of the dredge material, but given the restriction of other alternatives, it is a workable alignment. Use this alignment along the new berm. In addition, for aboveground installation the flexibility of HDPE allows more tolerance for inconsistent settling of the dredge material.

Lake fill force main along a straight line from the pond to the outlet near Spillway #3: This is no longer an option, as the outlet point was changed during the value engineering phase of this project. The outlet is now located near the southwest corner of the fill area.

Vertical for Lake Fill and MHS Force Mains

Several typical vertical alignments were analyzed for the location of the primary force main. A brief discussion of each follows.

Bury the primary force main below the maximum frost depth: This means 30" of cover to the top of the pipe and will thereby avoid potential heaving and thus joint leaks. This alignment would have been used with ductile iron pipe.

Bury the primary force main shallow: The cost to restrain joints and otherwise account for potential heaving during freeze-thaw cycles makes this alternative less desirable.

Build the primary force main on grade: The use of HDPE allows this option to be the most desirable. The durability of HDPE allows it to hold up in the corrosive salt air and not degrade under direct sunlight. Constructing on grade also solves the frost heave problems, as the pipe is flexible enough to withstand extreme heaves when placed aboveground. In addition, information obtained from the Plastic Pipe Institute assured us that residual water that was left in the pipe during the winter would have no impact on the life of the pipe. The pipe is designed to be flexible. Even a frozen pipe that is full, will flex when the water expands upon freezing, but return to its original shape upon thawing. The decreased cost of installation and the ease of locating and correcting pipe failures make this the best option.

Horizontal for MHS Force Main

The location of the MHS force main was chosen as the shortest path between the distribution wet well and the center of the Mudflat Hydration System. An alternative of feeding the Mudflat Hydration System from the end rather than the center was reviewed, but for hydraulic considerations, was deemed less desirable.

Special Considerations

Air Release

There is no design to include air release as the HDPE pipe is designed to expand and contract during freeze/thaw and other conditions.

Valves

There is no expected need to have valves along the force mains.

Dewatering

Dewatering of the force mains is not required. The HDPE material allows the pipe to be full of water and handle any deformation associated with freeze/thaw cycles. An anchoring system has been designed to keep the piping in a somewhat stable positions, rather than just allowing it to snake freely over the landscape when movement occurs due to expansion/contraction during freeze thaw. Concrete anchors are to be placed at 100 foot intervals, but the pipe will be free to bend or snake in between these points on the ground surface.

Maintenance Requirements

A quarterly review by observation, i.e. walking the pipeline to find defects, is suggested. In addition, any recommendations by the pipe manufacturer should be adhered to.

6.2.4 Mudflat Hydration System

General

In order to mimic the natural conditions of the mudflats being created for this project, water will be pumped to keep the mudflats wet. Several mechanisms to accomplish this goal have been analyzed.

Selection of Wetting System

Description of Alternatives

Overland Flow System

The overland flow system is currently being used in a wastewater treatment application at the Town of Easton, MD Wastewater Treatment Facility. The overland flow system is gravity fed through pipes installed on a gravel bed. The water is discharged through small weirs spaced along the pipes. Piping is manufactured specifically for this purpose of distributing flow evenly over a length, at a non-erosive rate. In the wastewater treatment application, a combination of physical, biological, and chemical processes renovate the wastewater as it passes over the surface of the terraces. In this application, the even and non-erosive distribution is the main desire.

Advantages: non-erosive flow rates

Disadvantages: gravity fed pipes are expensive to design and maintain on dredge material; hydration in a linear pattern relies on ground slopes for further hydration; hydraulically difficult to control and manage variations; vegetative growth around pipe can be problematic; debris either in the wastewater or blown by wind onto the weirs in the pipes can cause clogging and frequent maintenance.

Dribble System

The dribble system is a pressurized alternative of the overland flow system. The dribble piping would be installed on a gravel bed. The orifices in the dribble piping shall be located in an upward position. Galvanized steel has been assumed as the pipe material as it will be exposed to sunlight and weather. Because it will be above ground, clogged orifices can be readily observed and maintenance can be handled without excavation. It is assumed also that the pipeline could be cleaned, if necessary, by using a pressurized water jet system; regularly spaced clean outs will be necessary for access for such equipment. A valving arrangement should be designed such that when the piping is not pressurized it will be allowed to drain out freely which will reduce the risk of damage due to freezing pipe in cold weather.

Advantages: non-erosive flow rates; pressure pipe simplifies hydraulics

Disadvantages: hydration in a linear pattern relies on ground slopes for further hydration; vegetative growth around pipe can be problematic; clogging of the pipe orifices by material in the water or blown onto the pipe (leaves, plastic bags, etc.).

Underground Leaching

The underground leaching system is similar to the dribble system, but installed in a buried condition rather than on the surface.

Advantages: non-erosive flow rates; pressure pipe simplifies hydraulics

Disadvantages: hydration in a linear pattern relies on ground slopes for further hydration; relies on consistent soil conditions to convey ground water which may be problematic; more prone to clogging and harder to maintain.

Fire Hydrant Type Diffusers

The fire hydrant type diffuser system would essentially build a buried pressurized system with fire hydrants at spaced intervals. The hydrants would have flow diffusers permanently installed to distribute the flow at less erosive velocities.

Advantages: pressure pipe simplifies hydraulics; fire hydrants and diffusers easy to maintain; water is distributed over an area less dependent upon ground slopes

Disadvantages: water is sprayed over an area leading to erosion potential

Irrigation Sprinklers

The same system concept as the fire hydrant type diffusers, but using irrigation sprinkler heads spaced at intervals approximately three feet above grade. Sprinkler heads are manufactured specifically for use with raw water, distribution coverage is optimized and can be adjusted more easily. Maintenance of sprinkler heads is relatively easy.

Advantages: pressure pipe simplifies hydraulics; sprinkler heads are easy to maintain; water is distributed over a large area least dependent upon ground slopes

Disadvantages: water is sprayed over a large area with potential wind spray

Recommendations

The irrigation sprinkler system is the recommended alternative. The flow patterns will provide the greatest area of mudflat hydration. The reliability of the system is high as a pressurized system. And the maintenance of the system is one of the lowest of the alternatives.

Hydraulics for Recommendation

There are several manufacturers of these types of large irrigation sprinkler guns. In order to design the system, a specific rain gun had to be chosen to develop the hydraulics of the rest of the system. The sizing of the piping and pumps could not be determined without picking a certain gun. One of the Big Gun sprinkler heads from Nelson Irrigation was selected based on its relatively low flow and pressure requirements. If the successful contractor would like to use a different type of head, it would be totally acceptable, but would require a complete redesign of the pump and piping for the MHS system.

Based on the manufacturer's recommendation, the requirements were calculated based on maintaining 70 psi with 100' spacing to provide adequate coverage to create sheet flow with a 0.4" nozzle. The length of the west side of the fill area is approximately 3640 feet. Thus, 37 heads are required. The MHS force main is 14 inches in diameter and then splits off with a Tee connection to the northeast and southwest. The southwest pipe was sized to be 10 inches with 24 heads and the northeast pipe was sized to be 8 inches with 13 heads. The sprinkler guns themselves are placed on 3 foot high stainless steel risers connected by a Tee and anchored by large cast-in-place concrete bases. The sprinkler heads were chosen to be standard brass and aluminum assemblies, since the stainless steel heads were more than three times the cost of the standard heads.

Maintenance Requirements

No sprinkler head maintenance is anticipated. However, follow the manufacturer's recommendations that will be included in the O&M manual. The design included the requirement for the construction contractor to provide a replacement set of sprinkler heads.

6.2.5 Comprehensive Corrosion Protection

General

The corrosion evaluation field-testing completed on Hart-Miller Island determined that the soil and water on the island is very corrosive to metallic structures. Ductile iron or steel components, without protection, will fail very rapidly. Corrosion protection should be incorporated in the selection and design of all metallic components for this project that will be in contact with the soil and/or water. The corrosion protection measures should include proper material selection, dielectric coatings and cathodic protection, depending on the specific structure. Corrosion protection should also be included for all existing structures that are in contact with soil and/or water in order to maintain the integrity of these structures.

Materials Selection

Designing appropriate corrosion control measures for new metallic components that will be exposed to brackish water requires that special care be given to the forms and mechanisms of corrosion that can occur on these components in this environment. The basic forms of corrosion that can attack metals in brackish water are uniform corrosion, pitting corrosion, crevice corrosion and galvanic corrosion. Although all types of metals will corrode in brackish water, the proper selection of metallic components will significantly reduce corrosion attack and result in an increased useful life of the metallic components.

Steel and Iron Corrosion

Steel and iron readily corrode in many media including most outdoor atmospheres. Usually iron and steel are selected not for their corrosion resistance, but for their strength, ease of fabrication, and cost. Ordinary steels are essentially alloys of iron and carbon with small additions of elements such as manganese and silicon added to provide the requisite mechanical properties.

Iron and steels corrode in moist atmospheres. In water, and particularly in a brackish water environment, severe corrosion of iron and steel will occur. This corrosion activity will result in premature failure of iron or steel components. Properly designed coating and cathodic protection systems will stop corrosion from occurring on iron and steel components.

If it is determined that the spillway structure is structurally sound and will be maintained in place, corrosion protection must be implemented on all steel spillway surfaces that are to be submerged or exposed to the atmosphere in order to prevent additional corrosion from occurring on the structural members of the spillway.

Brass Corrosion

Brass alloys contain zinc as the principal alloying element with or without other designated alloying elements such as iron, aluminum, nickel and silicon. As a general rule, corrosion resistance decreases as zinc content increases. It is customary to distinguish between those alloys containing less than 15% zinc (better corrosion resistance), and those with higher amounts of zinc. The main problems with the higher zinc alloys are dezincification and stress corrosion cracking (SCC). In dezincification, a porous layer of zinc free material is formed locally or in layers on the surface. Dezincification in the high-zinc alloys can occur in a wide variety of acid, neutral and alkaline media. SCC occurs readily in the high-zinc brasses in the presence of moisture, particularly brackish water. Brasses containing less than 15% zinc can be used to handle many acidic, alkaline and salt solutions including brackish water without an increased level of significant corrosion attack.

Stainless Steel Corrosion

Stainless steels possess unusual resistance to attack by corrosive media at atmospheric and elevated temperatures, and are produced to cover a wide range of mechanical and physical properties for particular applications. Along with iron and chromium, all stainless steels contain some carbon. The carbon is added for the same purpose as in ordinary steels, to make the alloy stronger.

Stainless steels are mainly used in wet environments. With increasing chromium and molybdenum content, stainless steels become increasingly resistant to aggressive solutions, including brackish water. Austenitic steels are more or less resistant to general corrosion, crevice corrosion and pitting, depending on the quantity of alloying elements. Resistance to pitting and crevice corrosion is very important if the steel is to be used in chloride containing environments. Resistance to pitting and crevice corrosion typically increases with increasing contents of chromium, molybdenum and nitrogen.

Passive stainless steels, such as 304 and 316 stainless, are resistant to corrosion in many environments and can perform well over long periods of time. However, when corrosion does occur, the corrosion occurs as pitting, which will typically proceed quite rapidly. Relative resistance to corrosion can be described by the chloride concentration below which there is little likelihood of crevice attack occurring.

Pitting is most likely to occur in the presence of chloride ions when the 304 and 316 stainless steels are also subjected to low water velocity as will occur for the metallic components of the new slide gates. Both 304 and 316 stainless steels exposed to brackish water with high velocity (over 5 feet per second), which is the expected velocity of the water at the pump station submerged pumps, will typically perform very well for an extended period without serious corrosion damage. The high velocity brackish water will carry away corrosion products that would otherwise accumulate at crevices. Crevices can occur at any location where two metals are placed close to each other, but are not in intimate contact.

Recommendations

Corrosion protection measures should be incorporated in the selection and design of all metallic components for this project that will be in contact with the soil and/or water. Corrosion protection measures are also recommended for all existing metallic structures that are in contact with soil and/or water in order to maintain the integrity of the structures.

Existing Spillway

All existing and new steel members of the spillway structure are to be sandblasted and coated with dielectric coating from top of structure (elevation 32 feet MLLW) to 6 inches below the existing mudline or to an elevation of 11.5 feet MLLW, whichever is deeper. Excavate steel columns to the above required elevation prior to sandblasting and coating of the columns. A cathodic protection system consisting of aluminum galvanic anodes should be installed on the submerged portion of the spillway structure to provide corrosion protection to the steel members. After the completion of the installation of the cathodic protection system, and once the water level of the mudflat area has reached its expected level, testing should be performed to insure that the cathodic protection system is providing an adequate level of corrosion protection to the submerged steel members of the spillway structure.

Slide Gates

The slide gates and slide gate frames are to be constructed of FRP. Therefore, no corrosion protection is required for the slide gates or slide gate frames. The standard slide gate stem and stem hardware is constructed of type 304 stainless steel. Type 316 stainless steel can be provided for the slide gate stem and stem hardware as an option. Given the expected operating conditions of the slide gate, type 316 stainless steel should be specified for the slide gate stem and stem hardware.

Sprinkler Heads

The sprinkler heads can be constructed of brass or stainless steel. While the stainless steel sprinkler heads would be more resistant to corrosion from brackish water, the stainless steel sprinkler heads are three times more expensive than brass sprinkler heads. The stainless steel sprinkler heads are not expected to last three times longer than brass sprinkler heads. Therefore, the cost effective approach is that the sprinkler heads be constructed of brass and that they be replaced as necessary.

Submerged Pumps

As stated above, pitting corrosion is most likely to occur in the presence of chloride ions when both 304 and 316 stainless steels are also subjected to low water velocity as will occur when the pumps are not operating. Both 304 and 316 stainless steels exposed to brackish water with high velocity (over 5 feet per second), which is the expected velocity of the water when the pumps are operating, will typically perform very well for an extended period without serious corrosion damage.

The submerged pump manufacturers have recommended that stainless steel be chosen as the material of construction for the pumps due to the corrosive nature of the water. However, pitting corrosion will occur to certain types of stainless steels under low water velocity conditions, the conditions expected when the pumps are not in operation. In order to adequately assess the corrosion characteristics of the stainless steel selected for construction of the submerged pumps, the type of stainless steel must be specified. The installation of a galvanic cathodic protection system to provide corrosion protection to the stainless steel pumps should also be considered. However, before it can be determined if the stainless pumps can be adequately protected from corrosion with a galvanic cathodic protection system, details of the construction of the pump must be reviewed to determine if the application of cathodic protection is feasible.

Intake Screens

The intake screen manufacturers have recommended that the intake screens be constructed with a stainless steel body and backwash system piping with the screens themselves constructed of a copper/nickel alloy so that the screens will remain clean in water infested with Zebra mussels. Under high water velocity conditions, the condition expected when the pumps are in operation, the open circuit potentials of stainless steel and copper/nickel alloy are very close to each other and galvanic corrosion is not expected to be a significant problem. However, under low water velocity conditions, the open circuit potential of stainless steels becomes more negative than the open circuit potential of copper/nickel alloy. The result of this condition is that the stainless steel becomes anodic to the copper/nickel alloy and the stainless steel experiences galvanic corrosion.

Sprinkler Distribution Piping

The sprinkler system distribution piping is to be constructed of HDPE and is to be installed on the surface of the soil. No corrosion protection is required for the HDPE piping. However, if any of the HDPE fittings are metallic, corrosion control considerations must be incorporated into the material selection for the fittings. The final design of the sprinkler distribution piping should be reviewed to insure that there are no metallic components that will require corrosion control.

Other Metallic Structures

The design of the pump station, pump station piping, intake screens, sprinkler system, sprinkler system piping and spillway structure should be reviewed to insure that all metallic components in contact with soil and/or water are provided with appropriate corrosion protection or that the proper materials are selected to insure that the expected useful life of the component is achieved.

6.2.6 Maintenance

The selection of the proper materials of construction for the metallic components will result in a minimal amount of maintenance. If unusual corrosion conditions are observed on the metallic structures, a thorough review of the actual operating conditions and characteristics should be performed to determine the cause of the corrosion. Based on the findings of the review of operating conditions, alternate materials of construction should be selected and galvanic cathodic protection systems should be designed to provide adequate corrosion protection to the metallic structures.

The galvanic cathodic protection systems to be installed on the existing spillway structure, intake screens and, possibly on the pumps, should be tested after installation to insure that the structures are receiving an adequate level of corrosion protection. Annual testing of the galvanic cathodic protection systems is also recommended to insure that adequate levels of corrosion protection are maintained. Periodic replacement of the aluminum anodes will be required. The actual replacement periods will depend on the design life of the cathodic protection system and the actual operating conditions of the protected structures.

7.0 Planting Plan

A planting plan for the South Cell was developed which includes areas of uplands, wetlands, and forests. A breakdown of the proposed plants and quantities are listed in Table 7-1. Appendix F provides a list of possible plant material suppliers.

7.1 Uplands

All areas outside of the mudflat habitat are considered "uplands". All uplands will require liming to bring soil pH up to a minimum of 6.0. Based on an average pH of 3.5, 5 tons of lime per acre would be required to increase the pH to 6.0. The lime will be broadcast on the surface of the site so that soil disturbance does not occur. The application rate for the lime will be 2,099 lb/1,000 square yards. All upland areas will be seeded with the upland grass seed to provide erosion control, cover and habitat. Shrubs will be planted in strategic locations around the uplands, and a forest component will be added adjacent to the borrow pit.

Upland Grass/Forbs

The 121 acres of uplands will be seeded with a native upland grass/forb mixture. Species were selected for a range of tolerance to soil conditions, salinity, and drought. A wide range of grass species are include as well as several flowering species to increase diversity. Species under consideration include:

- Little Bluestem (*Andropogon scoparis*)
- Deertongue (*Panicum clandestinum*)
- Big Bluestem (*Andropogon gerardii*)
- Switchgrass (*Panicum virgatum*)
- Atlantic Coastal Panicgrass (*Panicum amarum*)
- Canadian Wild Rye (*Elymus canadensis*)
- Black eyed Susans (*Rubeckia trilobia*)
- Begger Ticks (*Bidens connata*)

At 17.5 pounds pure live seed per acre, seeding the site will require 2,117.5 pounds pure live seed. Native grass/forb mixes typically require 2-3 years to become fully established. In order to provide soil cover and erosion control during the establishment period, an annual grass species will be included in the mixture. Foxtail millet (*Setaria italica*), a warm season annual grass has been found growing successfully on the dredge material and will be used to provide erosion control. Foxtail millet will be seeded at a rate of 10 pounds per acre.

The soils will be treated as follows:

- Rough grading to achieve desired topography as part of site development
- Lime will be added to the upland soils in sufficient quantity to result in a pH 6.0
- The grasses will be planted with a no-till drill or prairie drill

This design eliminated the soil ripping to a depth of 6 inches due to concerns about soil disturbance increasing the invasiveness of existing *phragmites* stands.

Upland Shrubs

Approximately 6 acres of the upland areas will be planted with shrubs. The 35% design called for the use of container specimens 2-3 foot in height. For the final design, the size of shrub material was reduce to 18-24 inch due to a lack of availability of the larger size materials at the quantities required for this project. Shrubs will be planted approximately on 10-foot centers, for a total of 2,600 plants. The shrubs will be strategically placed to provide screening and cover along the mudflat perimeter and along the road.

Several salt tolerant shrub species will be planted, including but not limited to the following:

Groundsel Tree	*Baccharis halimifolia*
Hightide Bush	*Iva frutescens*
Wax Myrtle	*Myrica cerifera*
Bayberry	*Myrica pennsylvanica*

The following soil amendments may be incorporated into the planting soils:

- Lime
- Organic material (compost available on-site)
- Time-released fertilizer packs or tablets
- Water Absorbing Co-Polymer

Upland Forest

Approximately 12 acres of trees will be planted between the perimeter road and the pond (formerly the borrow pit). The acreage of upland forest was increased in the final design in order to extend the use of tree species around the entire borrow pit and along the hiking trail. The trees will screen the pump station from the perimeter road, as well as provide additional habitat diversity. Plant species typical of barrier islands or back dune areas were selected which will be able to tolerate the well drained sandy soils in this part of the island, as well as salt spray and saline soils. These species also have specific wildlife value, either cover or fruits, which will benefit migratory songbirds. The species proposed include:

- Pitch pine (*Pinus rigida*)
- Black Cherry (*Prunus seratina*)
- Beach Plum (*Prunus maratina*)
- Sassafras (*Sassafras albidum*)
- Eastern Red Cedar (*Juniperus virginiana*)

Trees will be planted on average of 20-foot centers for a total of 1,350 plants. The final plans cluster the trees to provide screening and patches of habitat. Plant material will be #1 containers and 18-24 inches in height. As with the shrubs, the size of material was reduced in the final design to insure availability from the nursery industry. The forest areas will also be seeded with upland grass mixture to provide soil stability and cover. Some of the upland shrubs may also be planted in this zone to provide additional plant diversity.

7.2 Wetlands

Wetland plants will not be intentionally planted in the mudflat habitat area since dense vegetation is not desirable for shorebird habitat. However, wetland plant species are anticipated to establish within the mudflat area. During flooding periods (winter and summer), waterfowl will bring wetland seeds to this habitat. The seed adapted to the specific salinity and water fluctuation conditions at the site will germinate. This approach to providing wetland plants within the mudflat area minimizes costs while allowing the species most adapted to this habitat to establish.

Tidal Wetlands

The pond (borrow pit) will be open to the saline waters of the Chesapeake Bay. On average, salinity fluctuates seasonally from 5 to 12 parts per thousand (ppt), with extremes of 1 to 17 ppt. Based on these salinities, a typical tidal wetland system could develop within the pond. However, the daily fluctuation of water elevations will not mimic a normal daily tidal cycle. Due to concerns about elevated pollutant concentrations in the pond, water will be allowed to flow into the pond from the Chesapeake Bay, not allowed to flow from the pond to the Chesapeake Bay. Thus water elevations within the pond will stabilize at about the mean high water elevation, with minimal daily fluctuations.

The wetlands within the pond will be composed of species tolerant of brackish water, but which also are tolerant of relatively stable water elevations instead of a regularly fluctuating daily tidal cycle.

The shoreline of the pond will be graded to provide a "safety bench". This area will be between 10 and 20 feet wide, with water depths up to 24 inches. Wetland vegetation will be planted along the bench in a zone from 6 inches above the anticipated water level to 6 inches below. At a 10:1 slope, this wetland fringe should be approximately 10 feet wide. The portion of the safety bench with water ranging from 6 to 24 inches deep will not be planted, but may be naturally colonized with wetland or submerged vegetation.

Wetland plant species adapted to the anticipated salinity and water depths will be planted on 3-foot centers. The tidal wetland area is 1.2 acres. A total of 6,150 individual plants would be required to cover the 1.2 acres. The following species are anticipated:

- Marsh Hibiscus (*Hibiscus moscheutos*)
- Seashore Mallow (*Kosteletzkya virginica*)
- Common Threesquare (*Scirpus annilanus*)
- Saltmarsh Bulrush (*Scirpus robustus*)
- Soft Stem Bulrush (*Scirpus validus*)
- Salt Grass (*Distichlis spicata*)
- Hard Stem Bulrush (*Scirpus acutus*)

Most species will be planted as 2-inch peat pots, except for Marsh Hibiscus and Seashore Mallow which are available as quart pots.

7.3 Goose Fencing

Temporary fencing will be installed in the tidal wetland planting zone to exclude Canadian geese. The fencing shall consist of 1-inch by 1-inch wooden stakes, 4 feet long, installed on 10-foot centers throughout the tidal wetland planting zone. The stakes will be inserted into the ground a minimum of 1 foot. Cotton twin will be strung from stake to stake in two directions, parallel and perpendicular to the shore, in order to create a grid like pattern of twine over the tidal wetland zone.

Table 7-1 Hart-Miller Island
100% Design

ITEM DESCRIPTION		UNIT	UNIT COST	QUANTITY	COST
TIDAL WETLAND PLANTING (1.4 acres at 3 foot centers)					
Hard Stem Bulrush (2 " pp)	*Scirpus acutus*	EA	$1.50	925	$1,388
Saltmeadow Bulrush (2"pp)	*Scirpus robustus*	EA	$1.50	925	$1,388
Softstem Bulrush (2"pp)	*Scirpus validus*	EA	$1.50	925	$1,388
Common Threesquare (2" pp)	*Scirpus americanus*	EA	$1.50	925	$1,388
Salt Grass (2 " pp)	*Distichlis spicata*	EA	$1.50	925	$1,388
Saltmeadow cordgrass (2"pp)	*Spartina cynosuroides*	EA	$1.50	925	$1,388
Marsh Mallow (qt)	*Hibiscus moscheutos*	EA	$5.00	350	$1,750
Seashore Mallow (qt)	*Kosteletzkya virginica*	EA	$7.50	250	$1,875
SUBTOTAL				**6,150**	**$11,950**
FOREST PLANTING (6 acres at 20 foot centers)					
Pitch Pine (18-24")	*Pinus rigida*	EA	$12.00	260	$3,120
Beach Plum (18-24")	*Prunus maratima*	EA	$12.00	260	$3,120
Sassafras (18-24")	*Sassafrass albidum*	EA	$12.00	260	$3,120
Red Cedar (18-24")	*Juniperus virginiana*	EA	$12.00	260	$3,120
Black Cherry (18-24")	*Prunus serotina*	EA	$12.00	260	$3,120
SUBTOTAL				**1,300**	**$15,600**
UPLAND SHRUB PLANTING (6 acres at 10 foot centers)					
Groundsel Tree (18-24")	*Baccharis halimifolia*	EA	$12.00	650	$7,800
Hightide Bush (18-24")	*Iva frutescens*	EA	$12.00	650	$7,800
Wax Myrtle (18-24")	*Myrica cerifera*	EA	$12.00	650	$7,800
Bayberry (18-24")	*Myrica pennsylvanica*	EA	$12.00	650	$7,800
SUBTOTAL				**2,600**	**$31,200**
UPLAND SEEDING (104 acres of grasslands, plus 6 acres of forest)					
Liming		Ton	$100.00	605	$60,500
Seeding		Ac	$1,000.00	121	$121,000
					$181,500
INVASIVE SPECIES CONTROL		AC	$200.00	250	**$50,000**
SUBTOTAL ALL					**$274,650**
CONTINGENCY		%	0.10	274,650	$27,465
TOTAL ESTIMATED COST					**$302,115**

PER ACRE PLANTING COSTS	Total Acreage	Cost Per Acre
Tidal Wetlands (based on 3 foot centers)	1.3	**$9,409**
Trees (planting costs based on 20 foot centers)	11.9	**$1,311**
Shrubs (planting costs based on 10 foot centers)	6.0	**$5,200**
Upland Grass (includes seeding and liming the forest and shrub areas)	121.0	**$1,500**

NOTES

Costs do not include mobilization to island
Cost for trees and shrubs includes all soil admendments (fertilizer, copolymer)
Upland seeding costs includes seedbed preparation, seed, and placement of seed.
Liming assumes average pH of 3.5 raised to 6.0, requires 5 tons per acre
Assumes that upland grass, forest, and shrub areas needs lime and seed

8.0 Cost Estimate for 100% Design

A MCASES cost estimate for the 100% design level was developed. This cost estimate is a separate document from the design report.

9.0 Long-Term Monitoring Plan and Operation & Maintenance Plan

The development of a long-term monitoring plan for this project was not included in the scope of work for the 100% design. The monitoring plan will be developed by others as a separate document at a future date.

An operation & maintenance plan for the water distribution system is recommended. This plan was not included in the scope of work for 100% design.

APPENDIX A

GEOTECHNCIAL ANALYSES

Geotechnical Analyses
And Recommendations

REPORT OF GEOTECHNICAL ENGINEERING ANALYSIS AND RECOMMENDATIONS

PROPOSED
SOUTH CELL RESTORATION
HART-MILLER ISLAND

CHESAPEAKE BAY
BALTIMORE COUNTY, MARYLAND

Prepared for
Michael Baker Jr., Inc.

F&R Project No. C68-122G

February 21, 2002

SINCE 1881

FROEHLING & ROBERTSON, INC.

GEOTECHNICAL • ENVIRONMENTAL •
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Web Site: www.FandR.com

February 21, 2002

Michael Baker, Inc.
801 Cromwell Park Drive, Suite 110
Glen Burnie, Maryland 21061

Attn: Ms. Michele Monde

Re: **Report of Geotechnical Engineering Analysis and Recommendations**
Proposed South Cell Restoration
Hart-Miller Island
Chesapeake Bay - Baltimore County, Maryland
F&R Project No. C68-122G

Dear Ms. Monde:

Froehling & Robertson, Inc. has completed review of the current available plans and the subsurface exploration data for the referenced project. This study was conducted in accordance with our Subconsultant Agreement for Professional Services dated 17th day of July, 2001, and our related proposal letter dated May 10, 2001.

We appreciate the opportunity to be of service to you for this project. If you have any questions regarding this report, please contact our office.

Respectfully,

Froehling & Robertson, Inc.

Raymond Hansen, P.E.
Senior Geotechnical Engineer

Franklin D. Gresheim, P.E.
State of Maryland

STATE OF MARYLAND FRANKLIN D. GRESHEIM No. 8597 REGISTERED PROFESSIONAL ENGINEER

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Table of Contents

1. PURPOSE AND SCOPE OF SERVICES

This report presents our engineering evaluation of the subsurface exploration program for the proposed restoration construction of the South Cell at Hart-Miller Island in the Chesapeake Bay - Baltimore County, Maryland. Location of the site is indicated on the Site Location Map, Drawing No. 1 in Appendix II. For this study, we have considered results of the recent program of test borings and soil laboratory testing completed in 2001 by the U.S. Army Corps of Engineers, Baltimore District (CENAB), and previous test borings and soil laboratory testing completed in 1998 by Earth Engineering and Science, Inc. (E2SI).

The subsurface investigation data available for this study and related plans for the proposed construction have been considered to develop the following:

1. Description of the site and presentation of subsurface test boring data, including boring location plan drawings.

2. Recommendations for support of the proposed Pump Station. Recommendations are given for feasible foundations, including allowable soil bearing pressure, estimated foundation subgrades, and estimated settlement. Recommendations are included regarding uplift considerations.

3. Recommendations regarding borrow pit excavations at the proposed North Pond construction, including finished allowable slopes.

4. Recommendations regarding grading for the proposed Perimeter Berm embankments along the south and west sides and also the proposed fill to be placed for the Nesting Island in the southeast portion of the project. Estimated amount and rate of settlement, allowable finished slopes, requirements for fill material and compaction, and assessment of on-site soils for re-use in the site grading, are included. General recommendations are included regarding placement of fill over soft subgrades.

5. Recommendations regarding proposed retrofit construction for the existing Spillway No. 3.

6. Recommendations for handling groundwater in the design and during construction.

7. Comments and recommendations regarding geotechnical construction considerations related to preparation of the construction plans and specifications.

Our scope of services does not include recommendations for temporary construction dewatering, allowable unsupported excavation slopes, stormwater management, flexible pavement section(s), erosion control, detailed cost or quantity estimates, final plan and specification documents, and construction observations and testing.

Our scope of services also does not include an environmental assessment for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements regarding odors, colors, or unusual or suspicious items or conditions are strictly for the information of the client.

2. PROJECT DATA

Proposed restoration construction considered for this study includes foundations for the Pump Station and retrofit construction for the existing Spillway No. 3, grading for Perimeter Berm embankments along the south and west sides, borrow excavations at the North Pond, and filling for the proposed Nesting Island. Details of the proposed construction available for this reporting are given in the following:

2.1 Pump Station and Transformer

Plans for the proposed pump station and valve vault indicate cast-in-place concrete structures with base slab subgrades at about El -19 and +10, respectively. Except for excavations for these structures, there will be little or no grading changes at this location. Finished exterior grades will be at about the existing grades which vary from about +10 to +20.

An estimated total dead load of 100 kips will be used for design of the main well structure. A maximum uniform load of less than 500 psf will apply for the base slab. For analysis of uplift, we understand the main wet well and dry pit structure will be designed based on the normal pond level of El 0.0.

2.2 Spillway No. 3

The existing Spillway No. 3 generally consists of steel H-pile framing with treated timber spanning between the piles. We understand the H-piles are believed to be embedded in a concrete mat base slab. Based on available data, we understand the mat subgrade is estimated to be at about El +6.

Restoration planned for this structure includes primarily attaching a new gate, galvanizing existing exposed steel, and adding some pre-treated timbers. We understand the total weight of this structure is estimated to be about 240 kips. This results in a uniform load of just over 700 psf based on a mat base slab measuring about 28 ft by 12 ft. The proposed restoration is estimated to result in a load increase of about 10 percent.

2.3 Perimeter Berm Embankment - South and West Sides

Most of the embankment will require about 2 to 4 ft of fill, but there are local areas requiring up to about 20 ft of fill. Finished embankment slopes are planned at 4H:1V and 10H:1V for the outside and inside face, respectively.

2.4 Borrow Pit Excavations - Proposed Pond

A pond area, which will be used for on-site borrow, is planned for the northwest portion of the project. Excavations up to about 10 ft depth are planned using a finished excavation slope of 10H:1V down to El -2, and a steeper finished slope of 4H:1V below this level to the proposed pond bottom at El -8.

2.5 Nesting Island Fill

Grading for a proposed nesting island in the southeast portion will include an average of about 3 ft of fill including a crushed oyster shell surface. Current plans for this grading indicate a proposed finished fill slope of about 4H:1V.

The proposed construction described above is according to the available 35% Submittal drawings provided to us and additional details of preliminary estimated loading and foundation subgrades provided by your office. Additional details affecting our analysis for this project are included in Section 5 herein.

3. EXPLORATION PROCEDURES

3.1 Field

Field investigation data for this study consist of the recent 2001 series of nineteen (19) test borings completed by the U.S. Army Corps of Engineers Baltimore District (CENAB) during September 5 thru 13, 2001. The previous 1998 series of ten (10) borings was completed by Earth Engineering and Science, Inc. (E2SI) during February 27 thru March 5, 1998. Locations of both series of test borings are shown on the Boring Location Plan, Drawing Nos. 2(C-01) thru 2(C-04), in Appendix II. Field locations and ground surface elevations at the test borings were provided to us as noted on the enclosed test boring logs.

For the recent 2001 series test borings, B-10, -12, -13, and -15 thru -19, were logged by our on-site field representative. The remaining 2001 series test borings were logged by the CENAB field representative. Unified Soil Classification symbols included on the enclosed 2001 series test boring logs have been added based on soil descriptions provided by the field representative. A key to the system nomenclature is provided in Appendix III. Also included in Appendix III is a reference sheet, which includes the descriptive terms used on the boring logs and description of the Standard Penetration Test.

For the enclosed logs of previous 1998 series borings, we have added ground surface elevations based on survey data given on the location plan drawing provided by the U.S. Army Corps of Engineers Baltimore District (CENAB).

3.2 Lab

Laboratory soil testing conducted on selected samples was provided by CENAB for the 2001 series test borings, and by E2SI for the 1998 series test borings. This included natural moisture content and Atterberg limits tests to aid in the general soil identification, and triaxial compression and direct shear tests to aid in determining soil strength parameters. Results of the laboratory soil testing are given by the laboratory test results summary sheets and test curves in Appendix IV.

4. SITE AND SUBSURFACE CONDITIONS

4.1 Site Conditions

The site is an island in the Chesapeake Bay southeast of Baltimore. The location is shown on the Site Location Map, Drawing No. 1, in Appendix II.

The existing ground surface generally consists of a perimeter berm, with top surface at about El 24, and an interior mudflat area which is mostly level at an average grade of about El 17. Existing structures include two spillways which consist of a system of steel columns with a baffle timber wall spanning between these structural elements. There are 36-inch diameter storm pipes behind the baffle wall, and a meshed plastic decking for access to the slide gates for controlling flow of water.

4.2 Subsurface Conditions

4.2.1 Stratification

Stratum A – Brown, dark brown, reddish brown, gray and black, dry to moist, very soft to medium stiff or very loose to loose, SANDY CLAY (CL), CLAY (CL), SAND (SP), and GRAVELLY SAND (SP), with iron oxide stains, trace grass and roots at some locations. At the ground surface, where encountered, to depths of 5 ft or to the bottom of borings at a depth of 11.5 ft. Standard Penetration Test (SPT) N-Values vary from weight of drill rods (WOR) to 11 blows per ft (bpf).

Stratum B – Light brown, dark brown and gray, dry to slightly moist, very loose to medium dense or soft to medium stiff, fine SAND (SP), fine SILTY SAND (SM), fine SANDY SILT (ML) and CLAY (CL and CH), trace shells at some locations. At the ground surface or below Stratum A to depths of 10 to 15 ft. SPT N-Values range from 3 to 16 bpf.

Stratum C – Dark brown, and gray to black, moist to dry, very loose to medium dense, fine SILTY SAND (SM) and fine to medium SAND (SP). Below Stratum A or B to depths varying from 12.5 ft to the bottom of borings at a depth of 31.5 ft. SPT N-Values range from weight of sampler hammer for 18 inches of sampler penetration (WH/18") to 33 bpf.

Stratum D – Light gray to dark gray, SILT (ML), fine SANDY SILT (ML), CLAYEY SILT (ML), and fine SILTY SAND (SM), with lenses of clay, decayed wood and shell fragments at some locations. Below Stratum C to depths varying from 22.5 ft to the bottom of borings at a maximum depth of 41.5 ft. SPT N-Values range from 1 to 9 bpf.

Stratum E– Light brown, tan, light gray, and gray, dry to wet, medium dense to very dense, fine to coarse SILTY SAND (SM) and SAND (SP), with layers of fine SANDY SILT (ML) trace gravel and rock fragments. Below Stratum C or D to the bottom of borings at a maximum depth of 41.5 ft. SPT N-Values range from 4 to 81 bpf.

4.2.2 Groundwater

Groundwater levels recorded in long term readings for the recent 2001 series test borings indicate water levels ranging from El +5.8 to El. +10.1. Short term readings, including those taken in the previous 1998 series borings, generally indicate higher water levels up to about El +14 to El +19. Water levels of the interior areas are anticipated to vary widely with variations from sandy to clayey soil profiles. For areas of relatively free-draining sandy subsoil, the water level should generally be within a few feet above nearby drainage channels. Higher levels, possibly within a few feet below the ground surface may be expected for areas of clayey subsoils. The groundwater readings included on the enclosed test borings logs are considered accurate for the times shown. Piezometer wells are available as shown on the borings logs for use in future monitoring of groundwater levels. Generally, seasonal and yearly fluctuations of the water table should be expected with variations in precipitation, surface runoff evaporation, and other similar factors. The groundwater level at this site will also be influenced by the ongoing construction and controls including trenching and spillways.

4.3 Geology

The subsoil profile generally consists of artificial dredge fill and Pleistocene or Recent age natural lowland deposits overlying the Cretaceous age Potomac Group sedimentary deposits. The fill and natural lowland deposits, including Strata designations A thru D, are variable with some very soft or loose essentially normally consolidated soils. Stratum E is believed to be from the underlying Cretaceous age subsoils which are known to be highly overconsolidated, at least about 12 tons per square ft in excess of the existing overburden pressure.

5. ENGINEERING EVALUATION AND RECOMMENDATIONS

Generally, the proposed 4H:1V and 10H:1V finished slopes indicated on the available 35% submittal drawings should be feasible using granular soils anticipated to be available from the proposed borrow pit excavations. Also, shallow foundations should be feasible and are recommended for the proposed pump station. Soft subgrades will require special equipment and methods for the earthwork, and there will be significant long term settlement. Details given below regarding the North Pond excavations, Bay Connector Culvert, Perimeter Berm, Pump Station, Spillway Retrofit, and Nesting Island include considerations of stability of finished slopes, estimated settlements due to grading fill and structure loads, allowable soil bearing capacity, design subgrades, and requirements for resisting hydrostatic uplift load.

5.1 North Pond Excavations (Borings B-10 thru B-14)

5.1.1 Slope Stability

An overburden of generally unsuitable clay and silt is anticipated primarily for higher portions of the North Pond site area, above about El 5 to 15. Below this overburden, and extending down to the proposed pond bottom El -8, soils to be excavated are mostly granular. As shown by the North Pond Cross Section, Project Plan Sheet Number: C-05, the following finished slope gradients are planned:

Above El -2	10H:1V
Below El -2	4H:1V

To evaluate the above plan slope gradients, we have considered an estimated critical section as given by Project Plan Sheet Number: C-05.

Results of slope stability calculations are given by the North Pond Cross Section, Sheet No. 1, in Appendix I. Although a portion of this cross section will be from grading fill, for our analysis we have considered an estimated critical subsoil profile based primarily on the nearby Boring B-14. A groundwater surface, varying from the top of pond excavation slope at El +10 to the Normal Pond El 0, and soil parameters are shown on Sheet No. 1. This cross section drawing provides a plot of the ten most critical potential slope failure surfaces and lists the calculated factor of safety values, FS. The minimum value, FS = 2.39, is satisfactory.

Based on our slope stability analysis, which is illustrated by the above calculation summarized on Sheet No. 1, we believe the excavation slopes as planned will be generally stable. It may be noted that local existing ground slopes are steeper than the listing of design slope gradients. There may tend to be local and shallow sloughing of existing steep slopes. Generally, except for specific site areas where this may be a concern, we do not recommend excavations of existing apparently stable slopes in order to satisfy flatter design slope gradients.

5.1.2 Estimated Borrow Material - Fill Material Specification

Considering the estimated subsoil profile noted in Section 5.1.1 above, we believe it should be practical to use selective stockpiling of excavations and a dredging operation to provide a basically granular borrow from the proposed North Pond excavations. Soils classifying SM, SC and SP are anticipated. For the general grading fill for the proposed Perimeter Berm and Nesting Island, we recommend specifying SM, SP, SW, GW, GC, or GM or better Unified Soil Classification.

5.2 Bay Connector Culvert Excavation (Boring B-9)

As shown by the Bay Connection Culvert Profile, Project Plan Sheet Number: C-07, excavations down to about El -4 are planned using a maximum slope gradient of 3H:1V. Boring B-9 at this site location indicates generally stable and competent bearing granular subsoils. To evaluate this proposed excavation, we have considered an estimated critical section as given by Sheet Number: C-07.

Results of slope stability calculations are given by the Bay Connector Culvert Cross Section, Sheet No. 2, in Appendix I. The estimated critical subsoil profile, based primarily on the nearby Boring B-9, includes design parameters for the stable granular subsoils given thereon. A groundwater surface, varying from El +2 for the uphill or interior cell area to El 0, and soil parameters are shown on Sheet No. 2. This cross section drawing provides a plot of the ten most critical potential slope failure surfaces and lists the calculated factor of safety values, FS. The minimum value, FS = 2.67, is satisfactory. For the relatively stable soil conditions at this site area, it may be noted that more conservative estimates for the groundwater level would still be acceptable.

Based on our slope stability analysis, which is illustrated by the calculation reviewed above and Sheet No. 2, we believe the excavation slopes as planned will be generally stable.

5.3 Perimeter Berm (Borings B-1 thru B-8)

For most of the perimeter berm, about 2 to 4 ft of fill will be required up to the proposed finished top of berm at El 22. There are some portions with proposed fill depths up to 19 ft. Finished slope gradients of 4H:1V and 10H:1V are planned for the outside and inside berm faces, respectively.

The test borings indicate the subsoil profile for the proposed perimeter berm generally consists of a relatively firm desiccated crust, of variable thickness, overlying very soft or very loose clay or sand. At some locations along this proposed berm there may be little or no firm crust layer. Details of our analysis, as reviewed below, indicate acceptable general stability and significant long term settlement. Anticipated practical problems of earthwork construction are also reviewed below.

5.3.1 Slope Stability

The estimated existing condition of thin crust and very soft clay subsoil indicated by Boring 4, and the proposed grading at Berm Cross Section 4 indicated by Project Plan Sheet Number: C-11, are estimated to be the critical condition. Results of slope stability calculations for this location are given by the Berm Perimeter Cross Section 4, Sheet No. 3, in Appendix I. The estimated critical subsoil profile, based primarily on the nearby Boring B-4, includes design parameters for very soft clay and underlying relatively firm sand subsoils given thereon. A groundwater surface, varying from El +19 for the uphill or interior cell area to El 0, and soil parameters are shown on Sheet No. 3. This cross section drawing provides a plot of the ten most critical potential slope failure surfaces and lists the calculated factor of safety values, FS.

The minimum value, FS = 1.27, is marginally satisfactory. Additional evaluations of soil shear strength parameters and subsoil profile may be necessary or advisable. Some slope stabilization may be necessary in the final construction. This may include filling across the existing ravine at this location. A limited depth of filling may be adequate.

Details may be determined based on more complete grading and/or subsoil data. For the present design, we recommend using the proposed finished berm slopes indicated by the existing plans. Details for a contingency plan, which would generally consist of filling across the ravine at selected locations, should be developed and included in the final plans. As applicable, the final bid documents should include related unit cost items for this additional grading.

5.3.2 Settlement

For most of the proposed berm, with fill depths of about 2 to 4 ft, maximum long term settlements on the order of 6 to 12 inches should be expected. For some portions with relatively firm subsoils, we estimate settlement values of about 1 inch or less. Significant differential settlement should be expected. This settlement, resulting primarily from long term consolidation of the very soft clay subsoils, should be expected to continue for more than a year after initial placement of fill.

It would not be practical to provide estimates of variations of settlement. For reasonable assurance of providing a top of berm at about El 22, we recommend overfilling an average of at least about 12 inches to allow for settlement. This overfilling will limit possible requirements for additional filling after settlement has occurred. Final adjustment to the design grade should be made after allowing at least one (1) year for settlement. Field monitoring, including periodic readings of settlement plates, can be used for scheduling of a final adjustment of grades.

5.4 Pump Station (Boring B-12)

The pump station base slab, minimum plan dimensions 17 ft x 24.5 ft, will be set at about El -19. Based on Boring B-12 at this location, we anticipate suitable bearing medium dense silty sand. Discounting hydrostatic uplift forces, a very low unit loading of less than 500 psf would apply for support of the total dead load of about 100 kips.

Subsoils anticipated at minimum depth are more than adequate, and hydrostatic uplift will be the controlling design consideration. Calculations based on the adjacent pond level of El 0 results in a total uplift load of just under 500 kips. This is resisted by the dead load of 100 kips plus additional download from the wedge of soil extending above the base slab.

For assurance that the soil backfill load is fully utilized, the base slab should be oversized to extend at least about 12 inches outside the pump station sidewalls. The base slab and connection to the sidewalls should be designed for the net uplift. For the recommended design using oversizing of the base slab, and including consideration of the design dead load of 100 kips, a factor of safety, FS = 1.8, applies. The base slab should be placed at minimum depth on the medium dense silty sand anticipated. A maximum net allowable soil bearing value of 1,000 psf may be used for design.

The estimated minimum depth subgrade, El -19 as noted above, may be used for setting design subgrade for the base slab. The recommended design bearing pressure includes a factor of safety of at least 3 against shear failure. Total settlement should be less than 1 inch.

5.5 Spillway Retrofit - Existing Spillway No. 3 (Boring B-1)

The spillway structure generally consists of steel pile columns set in a concrete base slab. The estimated total dead load of 240 kips results in a unit load less than 750 psf at the base. We understand the proposed retrofit will result in less than about 10 percent load increase.

Subsoils at the estimated base slab subgrade of El +6 consist of loose to medium dense silty sand. This subgrade soil is more than adequate for support of the estimated final unit loading, which is still less than 1000 psf. Settlement resulting from the increased loading will be very minor and imperceptible.

5.6 Nesting Island (1998 Series Borings B2, B3, B6 and B7)

Settlement matters affecting the design are reviewed below. General recommendations regarding problems of filling over very soft subgrades, which will be a significant construction problem, are included in Section 5.7 Earthwork.

Filling and a crushed oyster surface are planned for the proposed Nesting Island in the southeast portion of the site in an existing mudflat area. The average existing grade is about El 19, and the proposed finished surface grade is El 22.0. The available test borings indicate very soft clay at the ground surface extending to the bottom of borings at a maximum depth of 30 ft.

The soil description is generally silty clay, and available laboratory test results do not include soil identification or other testing to determine consolidation properties. Based on the silty clay soil description, and soil identification testing provided by for the nearby 2001 Series CENAB test boring samples, for our settlement analysis herein we have used estimated consolidation properties based on an assumed intermediate liquid limit value, LL = 50. We have used the following pertinent consolidation parameters:

Coefficient of Consolidation	$c_v = 0.2$ ft^2/day
Compression Index	$c_c = 0.4$

Long term consolidation settlement should be anticipated from the proposed fill. The total settlement will include primary compression plus relatively minor secondary compression. For our analysis herein we have considered only the primary compression.

We estimate long term settlement varying from about 5 to 10 inches at the edge and middle of Nesting Island, respectively. Based on our assumption of a lean clay soil, we estimate most of this settlement will occur during a period of about 2 months after initial loading.

5.7 Earthwork

Generally, except for an upper several inches of well developed highly organic turf cover, the crust material at the ground surface should be left in-place to aid support of construction traffic. The sandy soils anticipated below the clayey overburden should be used for the grading fill.

For some portions of the berm fill, a firm crust may be adequate for support of conventional earth moving equipment. However, access over very soft subgrades will be necessary for much of the proposed grading for the perimeter berm fill and for all of the proposed Nesting Island fill. Special equipment and procedures are anticipated to be necessary for handling areas of soft subgrade anticipated for this project.

For access over very soft subgrades, equipment for the earthwork should generally be light and track-mounted with smooth wide tracks to distribute loads. For some site areas, it may be necessary to end dump and spread ahead of heavy grading equipment.

Use of various prefabricated geotextile and/or geogrid materials may be necessary or desirable. For the subject island site, and a plan with very limited or no use of a preferred coarse graded crushed stone borrow for the initial lift, we recommend using a geogrid reinforcement and then a geotextile fabric separator placed directly over areas of soft subgrade. The on-site sandy soils would then be placed on the geotextile as the initial lift of fill. Consideration can be given to using only a geogrid. Depending on grading of in-place soils and the borrow fill, a geogrid may be effective as a separator as well as reinforcement over soft subgrade.

The geotextile and geogrid materials should be strong enough to resist tear during installation and the initial filling. Specific strength characteristics may be determined by the contractor to satisfy this or similar performance requirement, which should be used for the project specifications. For the geotextile, a minimum tear resistance of 100 pounds may be specified. This typical requirement for geotextile would be satisfied by Mirafi 500X. For the geogrid, Tensar Geogrid BX1200 or approved equivalent may be indicated in the specification.

Geogrid sheets should be placed using a minimum overlap of 3 ft. Ties may be used to prevent sheet separation. Approved alternate specific methods of filling, as may be suggested by individual contractors, should be permitted. Additional specific details for installation of geotextile and geogrid materials may be indicated by material suppliers.

At least about 18 inches loose thickness of sand fill should be placed prior to a significant compactive effort. Considering the intended use, and temporary surfacing for support of moderate to light and limited maintenance traffic, the recommended granular fill material should be adequately compacted using surface compaction over this initial lift. Subsequent lifts should be maximum 12 inches loose thickness. For fill material above the initial 18 inch lift, compaction to at least 90 percent density per ASTM D698 should be adequate.

6. CONSTRUCTION CONSIDERATIONS

6.1 Groundwater

Groundwater should be maintained at least about 1.0 ft below the final footing or base slab subgrades for the final subgrade observations and during placement of the foundation concrete. Excavations for the pump station will extend below water into permeable sandy subsoils. Well points or deep well dewatering methods are anticipated to be necessary for this construction.

6.2 Recommendations for Construction Monitoring

6.2.1 Shallow Foundations

Prior to placing concrete for foundation slabs, the excavations should be observed and tested as necessary to ascertain that foundations are placed on suitable subgrade in accordance with the recommendations given herein. Where reinforcing steel is to be placed in the foundations, observations should be provided to ascertain that proper chairs or supports are provided and the reinforcing is properly positioned.

Field observations and testing should also be provided for the earthwork construction for this project. This should include observations of subgrades prior to placing grading fill. Appropriate laboratory tests should be conducted on samples of the grading fill material, and field density tests should be conducted during the earthwork construction to ascertain that fill material and compaction requirements are being satisfied.

6.2.2 General

Field observations and testing indicated herein should be provided by our field engineer and/or technician personnel under supervision of our geotechnical engineer assigned to this project. We cannot be responsible for the interpretation or implementation, by others, of recommendations given herein.

6.3 Excavation Safety

Before beginning construction, the owner and contractor should become familiar with applicable local, state, and federal regulations, including the current OSHA Excavation and Trench Safety Standards. Construction site safety generally is the sole responsibility of the contractor, who should also be solely responsible for the means, methods, and sequencing of construction operations. We are providing this information solely as a service to our clients. Under no circumstances should the information provided herein be interpreted to mean that Froehling & Robertson, Inc. is assuming responsibility for construction site safety or the contractor's activities. This responsibility is not being implied and should not be inferred.

7. LIMITATIONS

This report has been prepared solely and exclusively to provide initial guidance to Michael Baker Jr., Inc. and other design professionals in developing plans and specifications. It has not been developed to meet the needs of others, such as contractors. Applications of this report for other than its intended purpose could result in substantial difficulties. The consulting engineer cannot be held accountable for any problems, which occur due to application of this report for other than its intended purpose.

This report should be made available to bidders prior to submitting their proposals and to the successful contractor and subcontractors for their information only, and to supply them with facts relative to the subsurface investigation, and laboratory tests, etc. The opinions and conclusions expressed in this report are those of the geotechnical engineer and represent his interpretation of the subsurface conditions based on tests and results of analysis and studies he has conducted for design.

Our recommendations are, of necessity, based on the concepts made available to us at the time of the writing of this report and on-site conditions, surface and subsurface, that existed at the time the exploratory borings were drilled. Any substantial changes in the proposed floor elevations, building loads, building location, or the site grading should be brought to our attention so that we may determine any affect on our recommendations given herein.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices.

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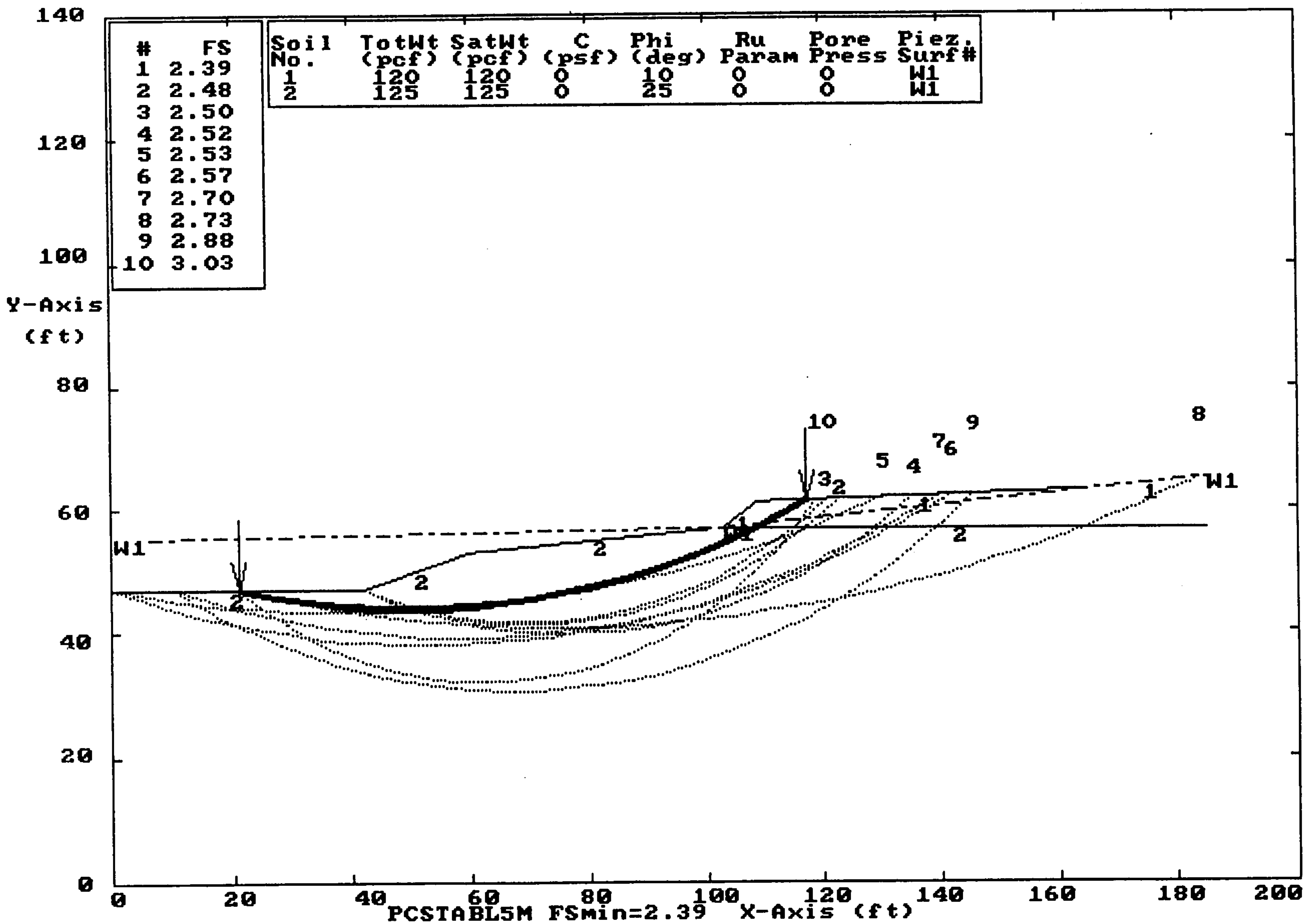
APPENDICES

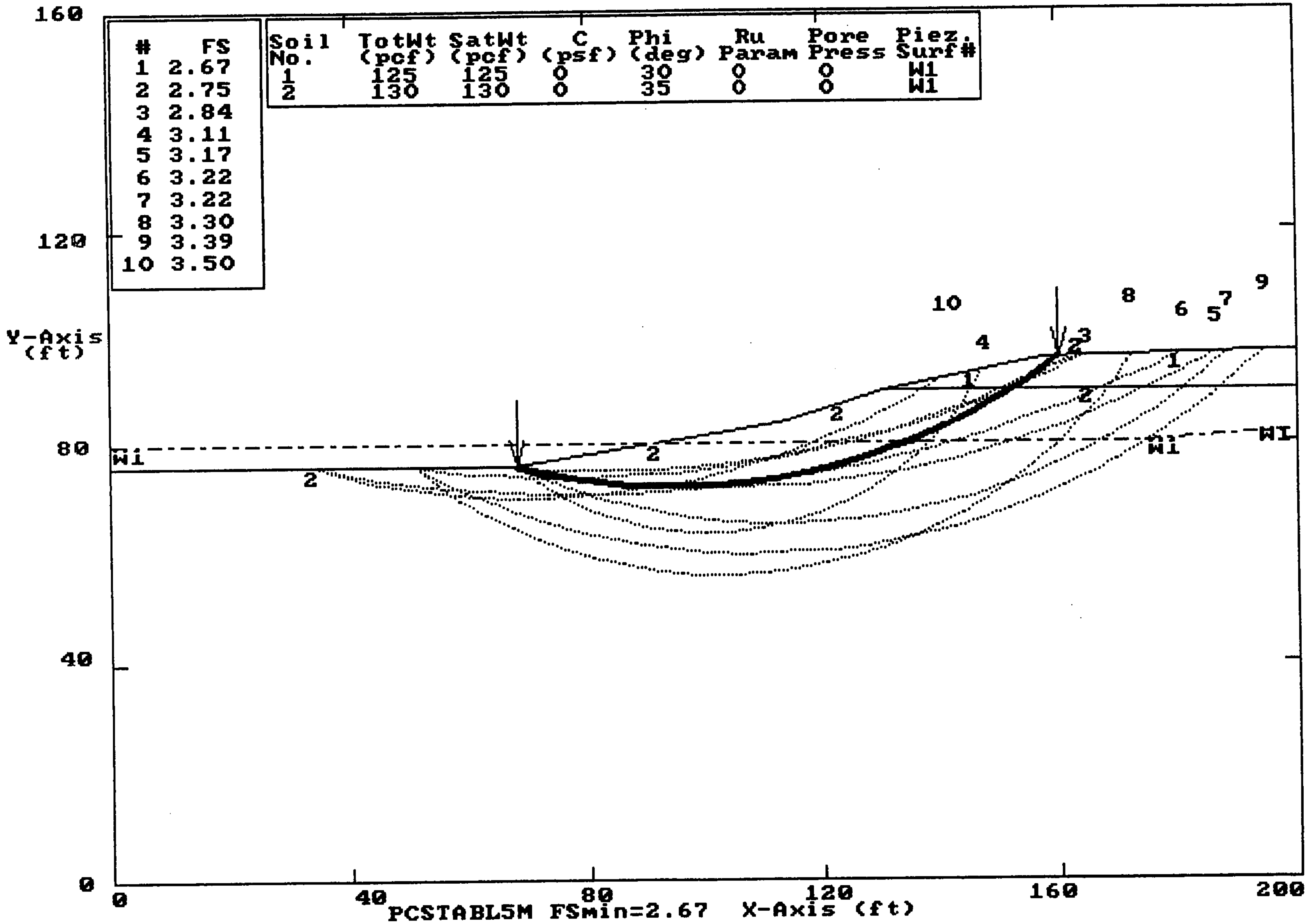
Appendix I	Slope Stability Analysis Sections North Pond, Sheet No. 1 Bay Connector, Sheet No. 2 Berm Perimeter, Sheet No. 3
Appendix II	Site Location Map, Drawing No. 1 Key Map, Drawing No. 1A Boring Location Plan, Drawing No. 2 (C-01 thru C-04)
Appendix III	Field Classification System for Soil Exploration Key – Graphic Soil Classification Chart Boring Logs 2001 Series (B-1 thru B-19) 1998 Series (B1 thru B10)
Appendix IV	Laboratory Test Results - 2001 by CENAB Summary (1 Sheet) Gradation Curves (13 Sheets) Laboratory Test Results - 1998 by E2Si Table: Summary (1 Sheet) Direct Shear Test (3 Sheets) Triaxial Test (4 Sheets)
Appendix V	Important Information about your Geotechnical Engineering Report

Appendix I

North Pond Cross Section, Sheet No. 1
Ten Most Critical. C:122NP04.PLT By: Frank Grefsheim 02-20-02 9:17am



Bay Connector Culvert Cross Section, Sheet No. 2
Ten Most Critical. C:122BC04.PLT By: Frank Grefsheim 02-20-02 10:01am

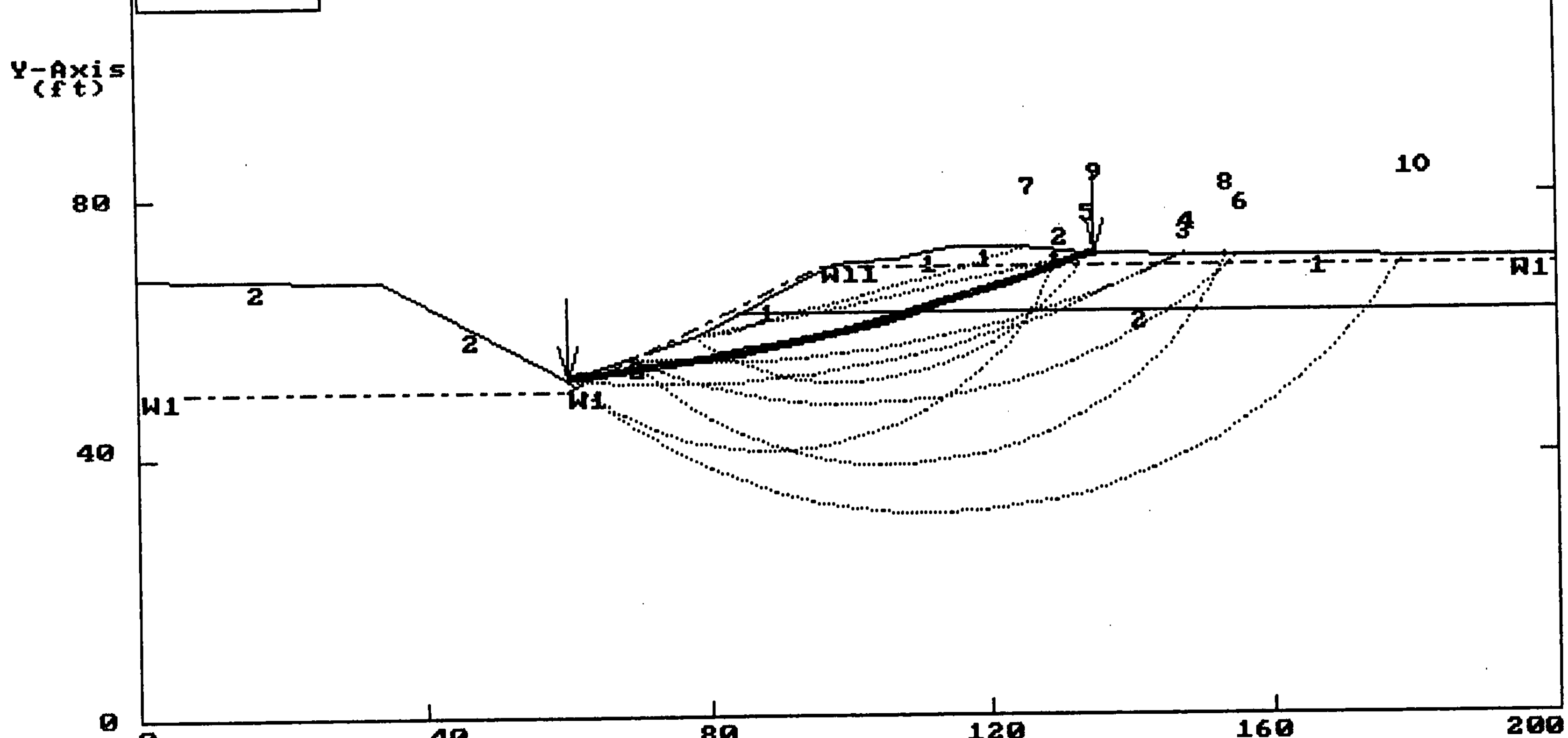


Berm Perimeter Cross Section 4, Sheet No. 3

Ten Most Critical. C:122PM05.PLT By: Frank Grefsheim 02-20-02 4:07pm

#	FS
1	1.27
2	1.28
3	1.33
4	1.59
5	1.79
6	1.86
7	2.27
8	2.32
9	2.37
10	2.60

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez. Surf#
1	120	120	250	5	0	0	W1
2	125	125	0	25	0	0	W1



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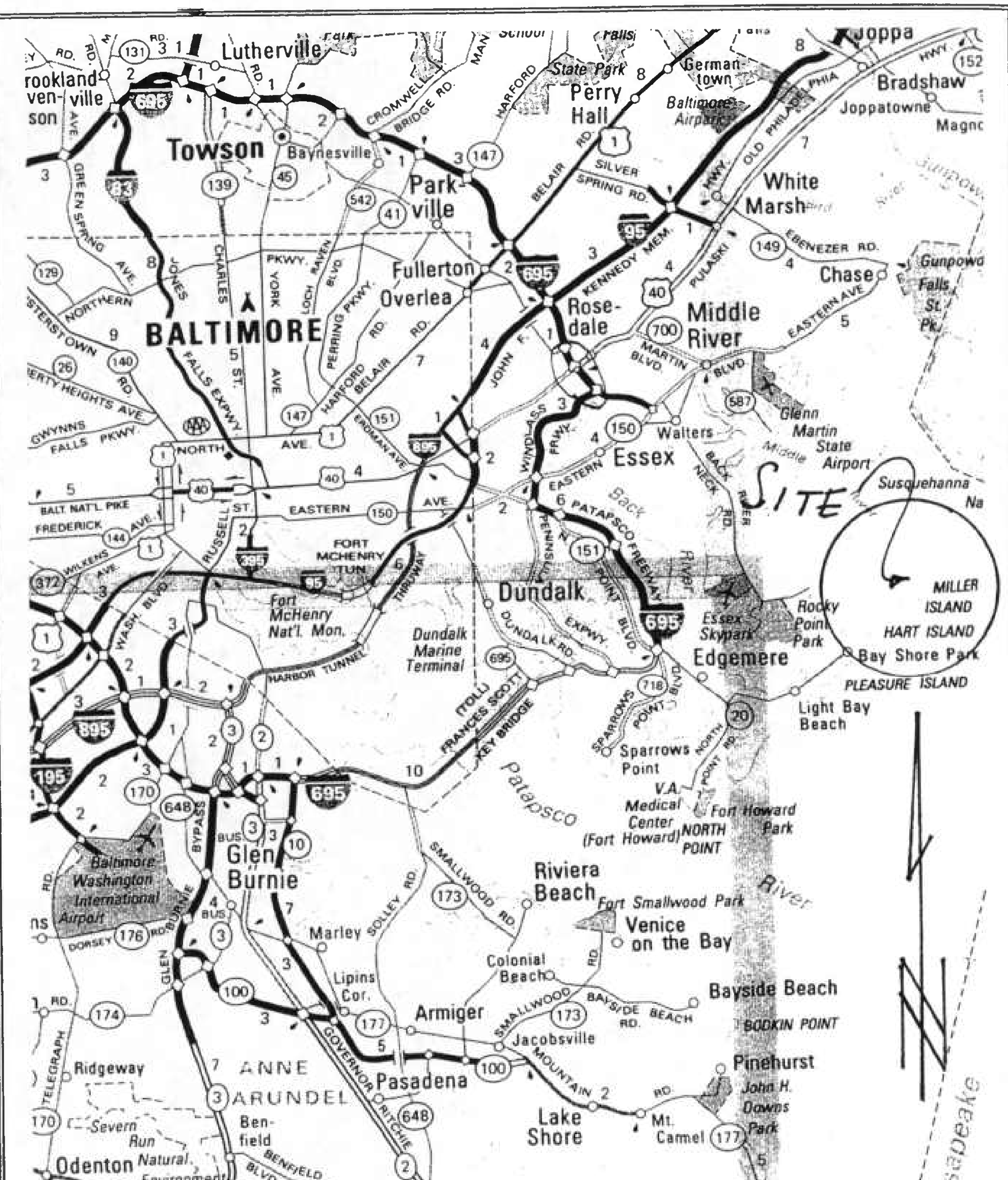
Appendix II



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FROEHLING & ROBERTSON, INC.

FULL SERVICE LABORATORIES - ENGINEERS & CHEMISTS

"OVER ONE HUNDRED YEARS OF SERVICE"

DATE:	Feb., 2002
SCALE:	NTS
BY:	FDG

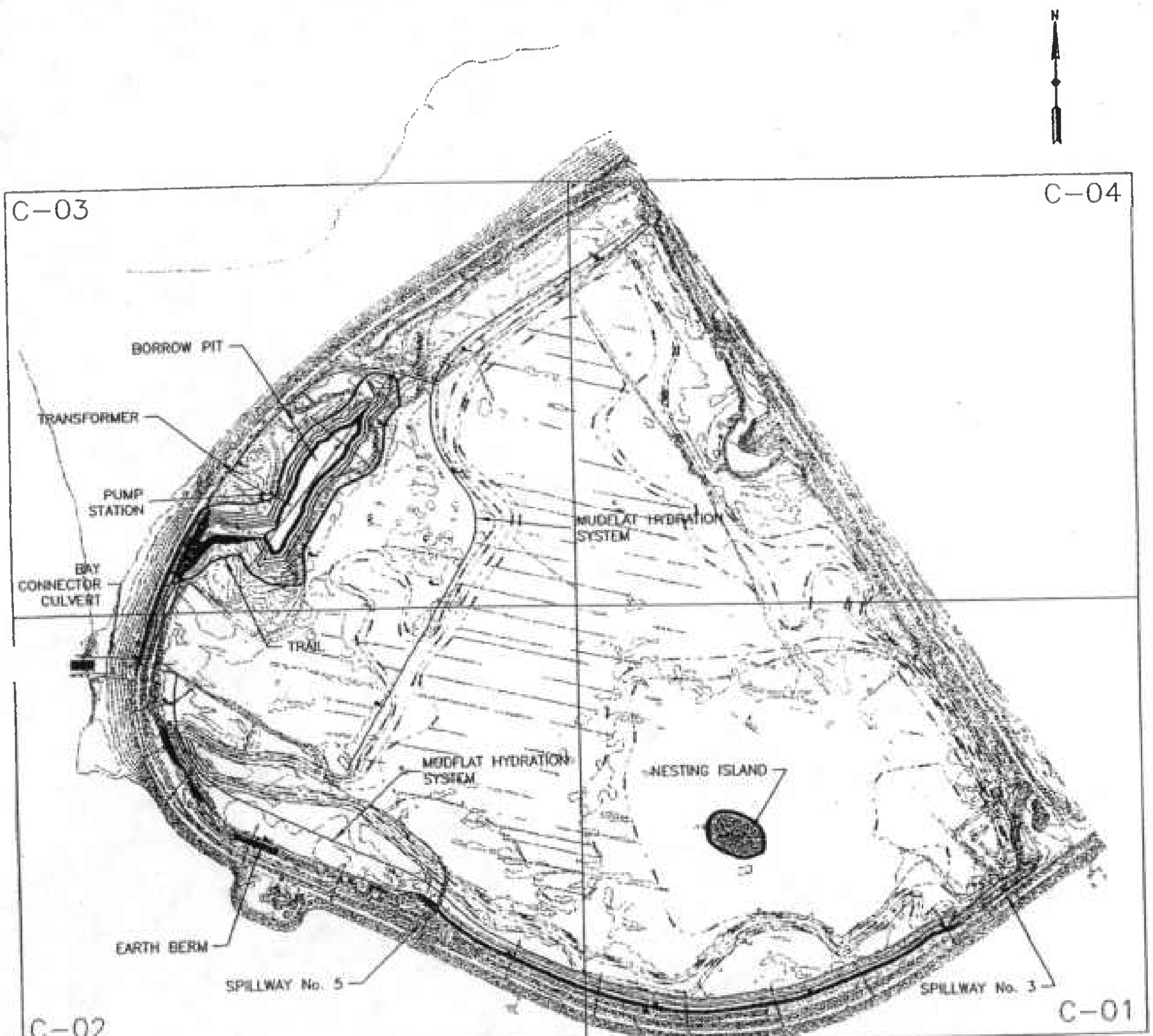
SITE LOCATION MAP

Proposed South Cell Restoration, Hart-Miller Island
Chesapeake Bay - Baltimore County, Maryland
F&R Project No. C68-122G

DRAWING NO.
1

drawing1.xls

HART-MILLER ISLAND
SOUTH CELL FINAL DESIGN
ENVIRONMENTAL RESTORATION
35% SUBMITTAL



Note: This drawing is a partial copy of the Title Sheet Key Map, Project Plan Sheet Number: T-01, dated 11/09/01, by US Army Corps of Engineers Baltimore District (CENAB).

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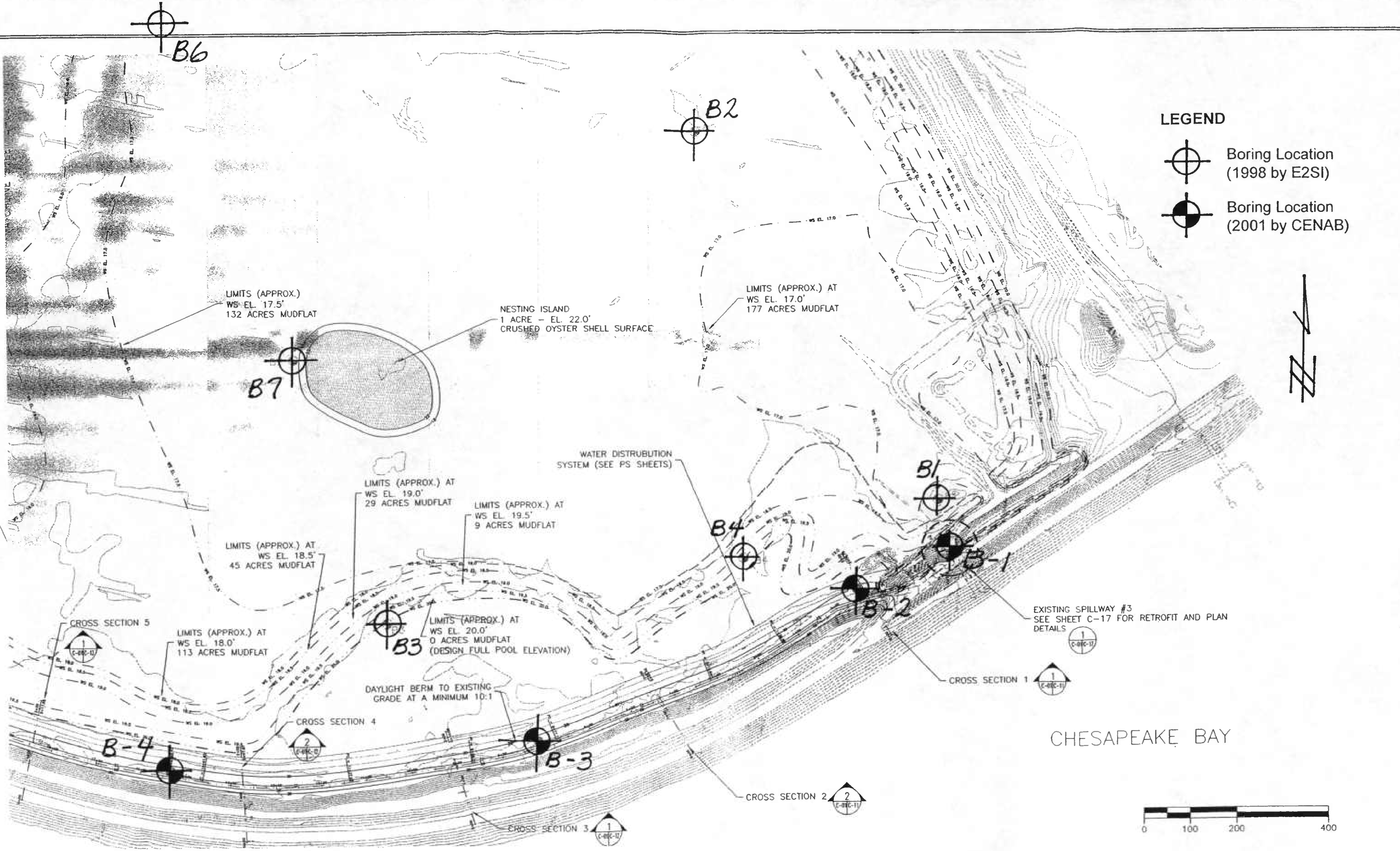
FULL SERVICE LABORATORIES - ENGINEERS & CHEMISTS
"OVER ONE HUNDRED YEARS OF SERVICE"

DATE: Feb., 2002
SCALE: NTS
BY: FDG

KEY MAP
Proposed South Cell Restoration, Hart-Miller Island
Chesapeake Bay - Baltimore County, Maryland
F&R Project No. C68-122G

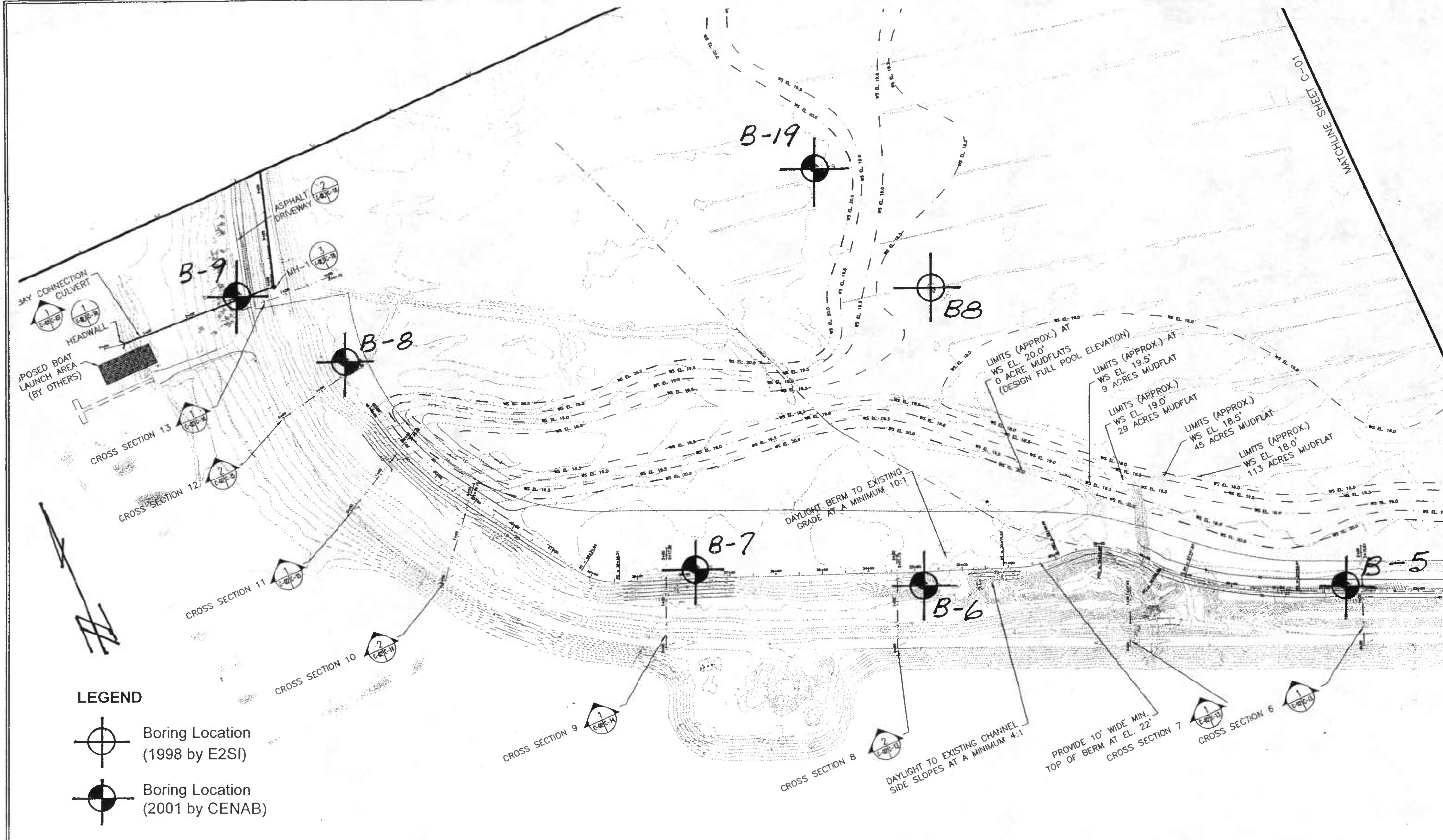
DRAWING NO.
1A

drawing1A.xls



Note: This drawing is a partial of the Site Plan drawing, Sheet Number C-01, dated 11/09/01, US Army Corps of Engineers Baltimore District (CENAB).

FROEHLING & ROBERTSON, INC. FULL SERVICE LABORATORIES - ENGINEERS & CHEMISTS *"OVER ONE HUNDRED YEARS OF SERVICE"*	DATE: Feb., '02 SCALE: 1" = 200' BY: FDG	**BORING LOCATION PLAN** Proposed South Cell Resotration, Hart-Miller Island Chesapeake Bay - Baltimore County, Maryland F&R PROJECT NO. C68-122G	DRAWING NO. 2(C-01)



LEGEND

Boring Location (1998 by E2SI)

Boring Location (2001 by CENAB)

Note: This drawing is a partial of the Site Plan drawing, Sheet Number C-02, dated 11/09/01, US Army Corps of Engineers Baltimore District (CENAB).

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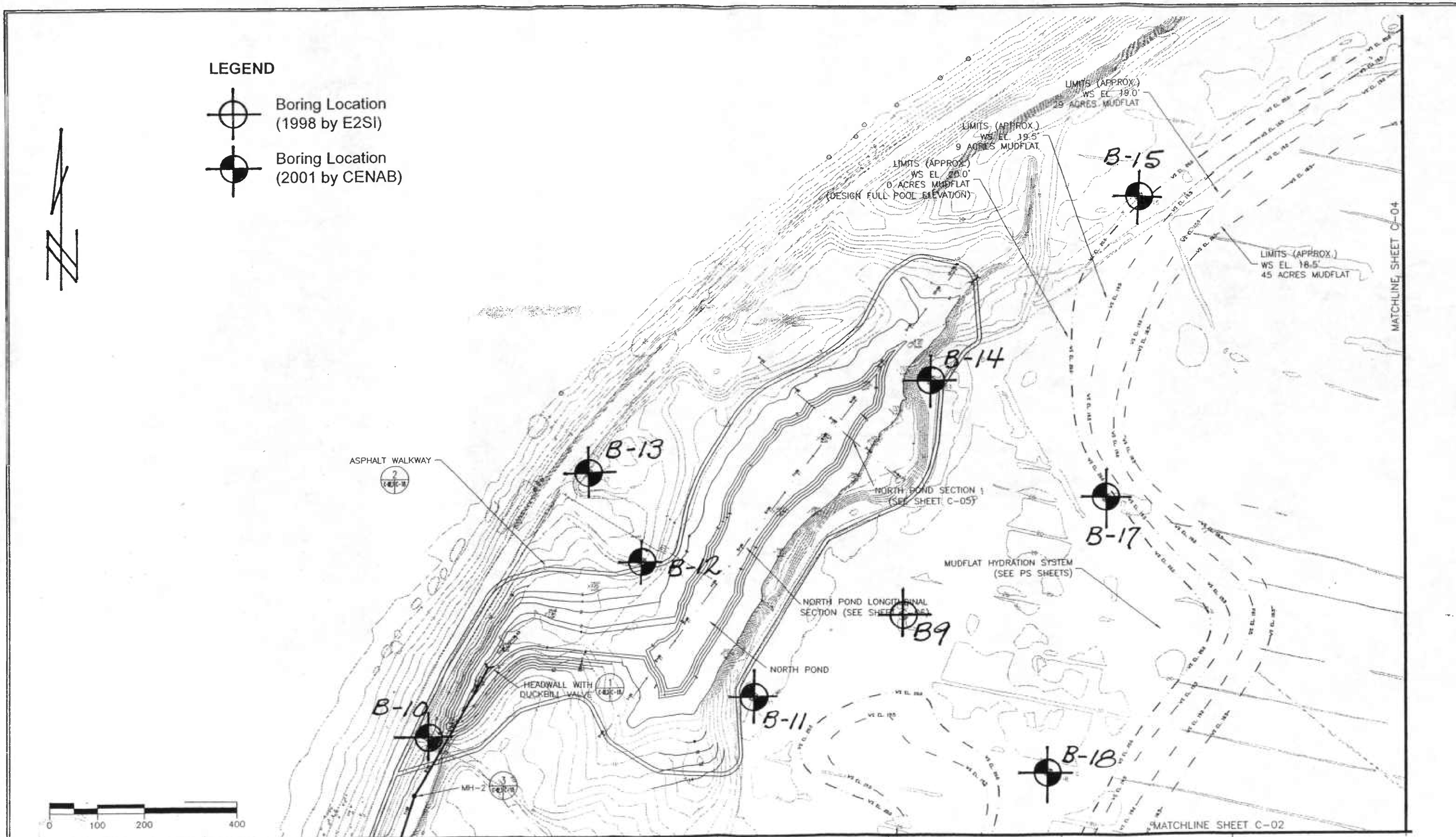

Note: This drawing is a partial of the Site Plan drawing, Sheet Number C-03, dated 11/09/01, US Army Corps of Engineers Baltimore District (CENAB).

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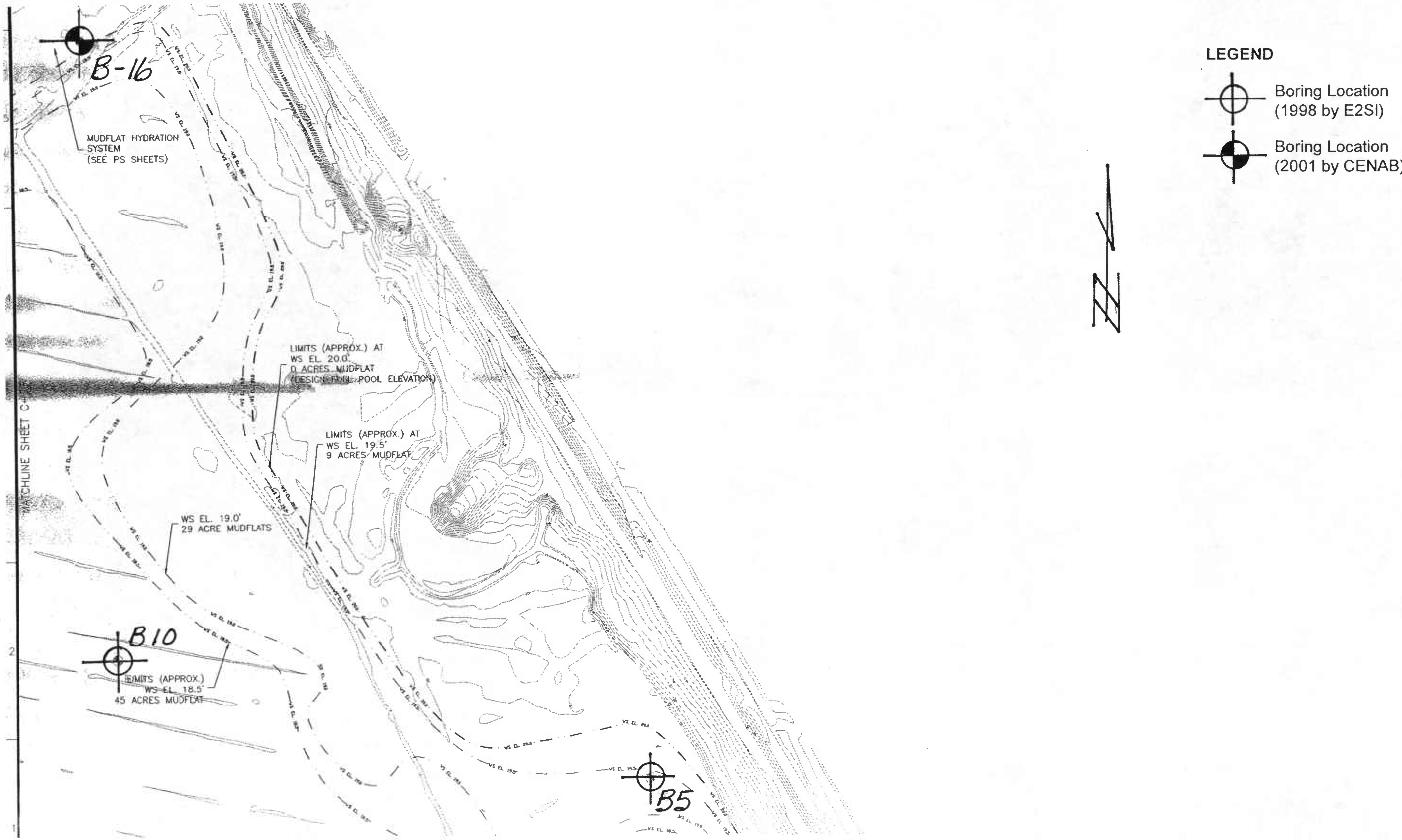


Note: This drawing is a partial of the Site Plan drawing, Sheet Number C-04, dated 11/09/01, US Army Corps of Engineers Baltimore District (CENAB).

FROEHLING & ROBERTSON, INC. FULL SERVICE LABORATORIES - ENGINEERS & CHEMISTS *"OVER ONE HUNDRED YEARS OF SERVICE"*	DATE: Feb., '02 SCALE: 1" = 200' BY: FDG	**BORING LOCATION PLAN** Proposed South Cell Resotration, Hart-Miller Island Chesapeake Bay - Baltimore County, Maryland F&R PROJECT NO. C68-122G	DRAWING NO. 2(C-04)

Appendix III

FIELD CLASSIFICATION SYSTEM FOR SOIL EXPLORATION

NON-COHESIVE SOILS

(Silts, Sand, Gravel and Combinations)

Density

Very Loose	- 5 blows/ft or less
Loose	- 6 to 10 blows/ft
Medium Dense	- 11 to 30 blows/ft
Dense	- 31 to 50 blows/ft
Very Dense	- 51 bpf or more

Relative Proportions

Descriptive term	Percent
Trace	1 to 10
Little	11 to 20
Some	21 to 35
And	36 to 50

Particle Size Identification

Boulder	- 8 inch or larger
Cobbles	- 3 to 8 inches
Gravel	- Coarse - 1 to 3 inch
	- Medium - ½ to 1 inch
	- Fine - ¼ to ½ inch
Sand	- Coarse - 0.6 mm to ¼ inch (dia. of pencil lead)
	- Medium - 0.2 mm to 0.6 mm (dia. of broom straw)
	- Fine - 0.05 mm to 0.2 mm (dia. of human hair)
Silt	0.002 mm to 0.05 mm (cannot see particles)

COHESIVE SOILS

(Clay, Silt and Combinations)

Consistency

Very Soft	- 3 or less blows/ft
Soft	- 4 to 5 blows/ft
Medium Stiff	- 6 to 10 blows/ft
Stiff	- 11 to 15 blows/ft
Very Stiff	- 16 to 30 blows/ft
Hard	- 31 bpf or more

Plasticity

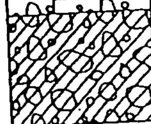
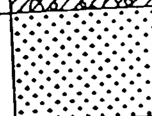
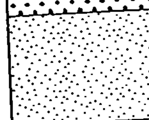
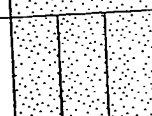
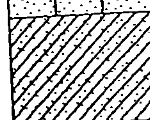
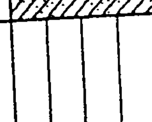
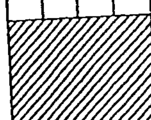
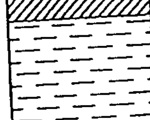
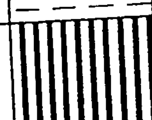
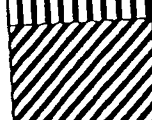
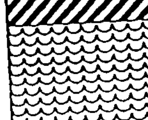
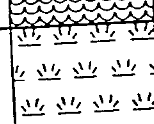
Degree of Plasticity	Plasticity Index
None to slight	0 to 4
Slight	5 to 7
Medium	8 to 22
High	over 22

Unified Soil Classification System (USCS) symbols on logs, per ASTM D2487, are made by visual inspection of samples.

Standard Penetration Test (SPT) Driving a 2″ O.D. (1 3/8″ I.D.) sampler a distance of 1 foot into undisturbed soil with a 140 pound hammer free falling 30 inches. It is customary for ATC to drive the spoon 6 inches to seat into undisturbed soil, then begin testing. The number of hammer blows for seating the spoon and testing are recorded for each 6 inches of penetration on the drill log (Ex. 6-8-9). The Standard Penetration Test "N-Value" can be obtained by adding the last two blow counts (Ex. 8+9 = 17). This test is conducted in accordance with ASTM D1586.

Groundwater Observations were made at the times indicated. Porosity of soil strata, weather conditions, site topography, etc., may cause changes in the water levels indicated on the logs.

GRAPHIC SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG

SINCE 1881

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-1 (1 of 1) Total Depth 31.5' Elev: 9.0ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/5/01 Completed: 9/5/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown and light brown, dry, loose to medium dense, fine, **SILTY SAND (SM)** trace to some gravel	5-8-8	0.0	16	
			5-6-6	2.5	12	
			4-3-3	5.0	6	
			2-4-5	7.5	9	
			7-6-6	10.0	12	
-3.5	12.5	Light brown, tan and light gray, dry medium dense to very dense, fine **SILTY SAND (SM)** with layers of fine SAND (SP), trace rock fragments below 17.5 ft.	6-9-13	12.5	22	
			6-8-10	15.0	18	
			10-18-23	17.5	41	
			14-46-35	20.0	81	
			9-11-14	22.5	25	
-16.0	25.0	Light brown to tan slightly moist, dense fine **SILTY SAND (SM)**, trace rock fragments	8-16-18	25.0	34	
-18.5	27.5	Brown, tan and gray, wet, dense, medium to coarse **SAND (SP)** trace gravel	9-17-18	27.5	35	Water encountered at 27.1 feet during drilling. Water recorded at 27.9 feet 24 hours after completion.
			11-15-16	30.0	31	
-22.5	31.5	Boring terminated at 31.5 feet				Approximate ground surface elevation provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.						
Project: South Cell Restoration, Hart-Miller Island, Maryland						
Boring No.: B-2 (1 of 1)	Total Depth 11.5'	Elev: 21.0ft ± *		Location: See Boring Location Plan		
Type of Boring: HSA		Started: 9/6/01	Completed: 9/6/02	Driller: McNamera		

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown to black, dry, medium dense, fine **SILTY SAND (SM)**, trace gravel and grass	3-6-5	0.0	11	
19.5	1.5	Dark gray and green-blue, moist soft to very soft **CLAY (CH)** (layer of reddish brown fine **SAND** (SP) from 7.5 to 7.9 feet)	2-3-2	2.5	5	
			WH-WH-1	5.0		
			WH-WH-3	7.5 8.3		No water encountered during drilling. Dry upon completion and after 24 hours.
11.0	10.0	Tan, dry, medium dense fine **SAND (SP)**	10-12-13	10.0	25	
9.5	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-3 (1 of 1) Total Depth 11.5' Elev: 19.6ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/6/01 Completed: 9/6/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light to dark brown and dark gray, dry to slightly moist, very soft to medium stiff, fine **SANDY CLAY (CL) and CLAY (CL)**	2-2-4	0.0	6	
			1-2-1	2.5	3	
14.6	5.0	Tan, slightly moist, loose to medium dense, fine **SAND (SP)**	5-8-10	5.0	18	
			3-4-4	7.5	8	Water encountered at 9.5 feet during drilling. Water level at 10.4 feet upon completion and 9.9 feet 24 hours after completion.
9.6	10.0	Dark brown and dark gray, wet, very loose, fine **SILTY SAND (SP**	1-1-2	10.0	3	
8.1	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-4 (1 of 1) | Total Depth 11.5' | Elev: 20.9ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/6/01 | Completed: 9/6/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown, dry, very loose fine **SAND (SP)** trace gravel, with iron oxide stains	1-1-2	0.0	3	
18.4	2.5	Dark gray and blue, moist, very soft **CLAY (CL)**	1-1-1	2.5	2	
			0-1-1	5.0	2	
			0-1-1	7.5	2	No water encountered during drilling. Dry upon completion and after 24 hours.
12.5	8.4	Light brown and tan, dry, very loose fine **SAND (SP)**	3-2-1	10.0	3	
9.4	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-5** **(1 of 1)**	Total Depth **11.5'**	Elev: **20.1ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/6/01**	Completed: **9/6/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Reddish brown, dry, loose gravelly SAND (SP) trace grass and roots	2-4-2	0.0	6	
17.6	2.5	Dark gray and brown, slightly moist, very soft to soft CLAY (CL) some iron oxide stains	2-2-2	2.5	4	
			0-1-1	5.0	2	
12.6	7.5	Brown and dark gray, slightly moist to dry, medium dense fine SAND (SP) (clay seams below 10 feet)	2-6-10	7.5	16	No water encountered during drilling. Dry upon completion and after 24 hours.
			6-8-11	10.0	19	
8.6	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-6** **(1 of 1)** Total Depth **11.5'** Elev: **24.5ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/6/01** Completed: **9/6/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown, dry, very soft fine **SANDY CLAY** (CL) trace grass roots and gravel to 1.5 feet	1-2-1	0.0	3	
			3-2-1	2.5	3	
			1-1-2	5.0	3	
17.0	7.5	Gray, dark gray and brown, very soft to soft **CLAY** (CL) with seams of fine sand	WOR-0-1	7.5	1	No water encountered during drilling. Dry upon completion and after 24 hours.
			WOH-1-3	10.0	4	
13.0	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**					
Project: **South Cell Restoration, Hart-Miller Island, Maryland**					
Boring No.: **B-7** **(1 of 1)**	Total Depth **11.5'**	Elev: **22.7ft ± ***		Location: **See Boring Location Plan**	
Type of Boring: **HSA**	Started: **9/6/01**	Completed: **9/6/01**		Driller: **McNamera**	

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown, dry medium dense, fine **SILTY SAND (SM)** trace roots and gravel	3-8-8	0.0	16	
20.2	2.5	Dark brown, slightly moist, loose **SAND (SP)** and shells, trace clay	4-3-4	2.5	7	
17.7	5.0	Dark brown and gray, slightly moist, medium stiff to soft **CLAY (CH)** (lenses of fine to medium sand, trace shells below 7.5 feet)	6-4-5	5.0	9	
			4-2-2	7.5	4	No water encountered during drilling. Dry upon completion and after 24 hours.
12.7	10.0	Light brown, dry, medium dense, fine, **SAND (SP)**	4-6-7	10.0	13	
11.2	11.5	Boring terminated at 11.5				
						*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-8 (1 of 1) Total Depth 11.5' Elev: 22.5ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/7/01 Completed: 9/7/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown, dry, medium stiff, fine SANDY CLAY (CL), with grass	2-3-3	0.0	6	
20.0	2.5	Dark gray to black moist, very soft CLAY (CL) (layer of dry fine to medium sand from 8.6 to 9.0 feet)	0-1-1	2.5	2	
			WOH/18"	5.0		
			WOH/18"	7.5		No water encountered during drilling. Dry upon completion and after 24 hours.
12.5	10.0	Dark gray to black, dry, medium dense SAND (SP)	4-7-11	10.0	18	
11.0	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**						
Project: **South Cell Restoration, Hart-Miller Island, Maryland**						
Boring No.: **B-9** (1 of 1)	Total Depth **31.5'**	Elev: **18.3ft ± ***		Location: **See Boring Location Plan**		
Type of Boring: **HSA**	Started: **9/7/01**	Completed: **9/7/01**		Driller: **McNamera**		

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Tan, dry, loose to medium dense **SAND (SP)** trace roots and grass to 1.5 feet (layer of dark brown, moist soft clay from 8.7 to 9.0 feet)	5-7-9	0.0	16	
			9-4-4	2.5	8	
			3-4-7	5.0	11	
			7-6-6	7.5	12	
8.3	10.0	Light gray to dark gray, moist to dry (wet at 13 feet and 20 feet), medium dense, fine to medium **SAND (SP)** (silt layer from 17.5 to 17.8 feet)	12-14-14	10.0	28	
			9-12-15	12.5	27	
			8-12-21	15.0	33	Piezometer well, consisting of one (1) inch diameter PVC tubing and 10 foot well screen (10-slot), installed to 28.5 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 5.9 feet, Sure-Plug bentonite backfill in upper 5.9 ft to ground surface. Finished well stick-up of 1.9 ft. Water encountered at 11.5 ft during drilling. Water recorded at 15.1 ft upon completion. Water recorded at 14.4 ft. below top of well 64 hours after installation.
			20-10-9	17.5	19	
			4-7-11	20.0	18	
-4.2	22.5	Dark gray to light gray, slightly moist to very moist, soft to medium stiff, **SILT (ML)** (lenses of clay and decayed wood below 28 feet)	1-1-3	22.5	4	
			2-3-2	25.0	5	
			1-3-3	27.5	6	
			WOR-2-2	30.0	4	
-13.2	31.5	Boring terminated at 31.5				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-10 (1 of 1) | Total Depth 31.5' | Elev: 12.7ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/10/01 | Completed: 9/10/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Brown to tan, moist, loose to very loose, fine **SILTY SAND**, some gravel	2-4-3	0.0	7	
			WH-2-1	2.5	3	
			2-3-4	5.0	7	
6.7	6.0	Gray, wet, medium stiff to stiff fine **SANDY SILT (ML)**	4-4-3	7.5	7	
			5-7-7	10.0	14	
0.2	12.5	Gray, wet, very loose to loose fine **SILTY SAND (SM)**	1-2-3	12.5	5	
			2-2-3	15.0	5	Water encountered at 6.0 feet during drilling
			2-3-2	17.5	5	Water recorded at 13.0 feet upon completion. Boring backfilled, no 24 hour readings
			1-2-1	20.0	3	
			4-4-3	22.5	7	
			4-3-2	25.0	5	
-13.3	26.0	Gray, wet, soft, **CLAYEY SILT (ML)**, some fine sand	1-4-9	27.5	13	
-15.3	28.0	Gray, wet, loose to medium dense, fine **SILTY SAND (SM)**	2-3-7	30.0	10	
-18.8	31.5	Boring terminated at 31.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG

SINCE 1881

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-11 (1 of 1) | Total Depth 31.5' | Elev: 22.2ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/12/01 | Completed: 9/2/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
22.0	0.2	Topsoil and roots Light brown, dry, very loose fine **SILTY SAND (SM)**	1-1-2	0.0	3	
19.7	2.5	Dark brown and dark gray to black, moist, very soft **CLAY (CH)** trace to some fine sand below 7.5 feet	2-1-2	2.5	3	
			WH-1-1	5.0	2	
			WH-WH-1	7.5		
			WH-1-1	10.0	2	
			WH-1-1	12.5	2	
7.0	15.2	Dark gray to black, wet very loose, fine **SILTY SAND (SM)**	1-2-3	15.0	5	Piezometer well, consisting of one (1) inch diameter PVC tubing and 10 feet well screen installed to 31.5 feet upon completion of boring. Annular borehole space backfilled with "0" well sand to 4.8 feet, Sure-plus ben tonite backfill in upper 4.8 feet to ground surface. Finished well stick up of 30-inches. Water encountered at 14.2 feet during drilling.
4.7	17.5	Dark brown and dark gray, wet, very loose, fine **SAND (SP)** with clay (dark gray to black below 22.5 feet)	1-1-1	17.5	2	
			1-1-1	20.0	2	
			1-1-1	22.5	2	
			1/2"-1	25.0		
			WH/18"	27.5		
			1/12"-1	30.0		
-9.3	31.5	Boring terminated at 31.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

BORING LOG

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.			
Project: South Cell Restoration, Hart-Miller Island, Maryland			
Boring No.: B-12 (1 of 2)	Total Depth 41.5'	Elev: 11.0ft ± *	Location: See Boring Location Plan
Type of Boring: HSA	Started: 9/11/01	Completed: 9/11/01	Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown to brown, moist very loose, fine **SILTY SAND (SM)**	1-2-2	0.0	4	
8.5	2.5	Black, moist, very soft **CLAYEY SILT (ML)** trace fine sand	3-1-1	2.5	2	
			WH-1-1	5.0	2	
			WH-1/12"	7.5		
2.1	8.9	Gray, wet loose to medium dense, fine **SILTY SAND (SM)**	3-4-6	10.0	10	
			4-5-6	12.5	11	
-3.5	14.5	Light brown, moist, very stiff **SILTY CLAY (CL)**	6-9-10	15.0	19	Piezometer well, consisting of one (1) inch diameter PVC tubing and 20 feet well screen, installed to 41 feet upon completion of boring. Annular borehole space backfilled with "0" sand to 4.8 feet, Sure-plus Ben Tonite backfill in upper portion to ground surface. Finished well stick up of 30-inches. Water encountered at 8.9 feet during drilling. Water recorded at 7.1 feet upon completion.
-5.0	16.0	Light brown, wet, loose fine **SAND (SP)**	3-4-3	17.5	7	
-8.0	19.0	Gray, moist to wet, very loose fine **CLAYEY SAND (SC)**	1-1-2	20.0	3	
			3-3-6	22.5	9	
-12.0	23.0	Gray, wet, medium stiff **CLAYEY SILT (ML)** with fine sand	1-1-2	25.0	3	
-14.5	25.5	Gray, wet, very loose to medium dense fine **SILTY SAND (SM)**	1-4-5	27.5	9	
			4-10-10	30.0	20	
			4-5-5	32.5	10	
			4-6-5	35.0	11	
			3-4-5	37.5	9	
-28.0	39.0	Gray, moist, soft, fine **SANDY SILT (ML)**, trace				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG

SINCE 1881

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-12** (2 of 2)	Total Depth **41.5'**	Elev: **11.0ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/11/01**	Completed: **9/11/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		clay	1-2-2	40.0	4	
-30.5	41.5	Boring terminated at 41.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

BORING LOG

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Report No.: C68-122G
Date: 1-30-02

Client:	Michael Baker Jr., Inc.
Project:	South Cell Restoration, Hart-Miller Island, Maryland
Boring No.:	B-13 (1 of 2)
Total Depth	41.5'
Elev:	11.6ft ± *
Location:	See Boring Location Plan
Type of Boring:	HSA
Started:	9/11/01
Completed:	9/12/01
Driller:	McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown and gray, moist, very loose to medium dense like **SILTY SAND (SM)**, some gravel, layer of very soft clayey silt firm 1.0 to 1.5 ft	2-1-1	0.0	2	
			6-6-5	2.5	11	
7.1	4.5	Tan, moist, medium dense to dense **SILTY SAND (SM)** with lenses of silt (black and wet below 6.5 ft)				
			4-10-13	5.0	23	Water encountered at 6.5 ft during drilling. Water at 8.4 ft upon completion.
			9-13-18	7.5	31	
			5-3-9	10.0	12	
			1-2-6	12.5	8	
			4-12-14	15.0	26	
-3.9	15.5	Tan, wet, very loose to medium dense, fine **SAND (SP)**				
			1-2-1	17.5	3	
			3-5-4	20.0	9	
-9.4	21.0	Gray, wet, very loose to medium dense fine **SANDY SILT (ML)**				
			8-2-2	22.5	4	
			2-7-8	25.0	15	
			4-9-9	27.5	18	
-16.4	28.0	Gray, wet, medium dense to loose, fine **SILTY SAND (SM)**				
			3-6-14	30.0	20	
			7-9-9	32.5	18	
			3-4-6	35.0	10	
-24.4	36.0	Gray, moist to wet, very loose fine **SANDY SILT (ML)** trace clay				
			2-2-2	37.5	4	

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-13 (2 of 2) | Total Depth 41.5' | Elev: 11.6ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/11/01 | Completed: 9/12/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
			2-2-2	40.0	4	
-29.9	41.5	Boring terminated at 41.5 ft				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-14 (1 of 1) Total Depth 31.5' Elev: 24.9ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/12/01 Completed: 9/13/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	3-4-4	0.0	8	
24.1	0.8	Dark gray, dry, loose to very loose, fine **SILTY SAND (SM)**	1-1-1	2.5	2	
21.4	3.5	Black, moist, very soft **CLAY (CH)** trace fine sand sand	WH-1-1	5.0	2	
			WH-1-1	7.5	2	
14.9	10.0	Dark gray to black, dry very loose to loose fine **CLAYEY SAND (SC)** and **SILTY SAND (SM)**	1-1-2	10.0	3	
			3-3-3	12.5	6	
9.9	15.0	Dark gray to black, wet very loose, fine to medium **SAND (SP)** trace shell fragments	2-2-1	15.0	3	Piezometer well, consisting of one (1) inch diameter PVC tubing and 20 foot well screen (10-slot), installed to 29.0 ft upon completion of boring. Annular borehole space backfilled with # well sand to 6.9 ft, Sure-Plug bentonite backfill in upper 6.9 ft to ground surface. Finished well stickup of 2.5 ft. Water encountered at 14.5 ft during drilling. Water recorded at 17.3 ft below top of stick-up upon completion of well installation. Water recorded at 17.0 ft below top of well 4 days after installation.
			1-1-2	17.5	3	
4.9	20.0	Dark gray to black wet, very soft fine **SANDY CLAY (CL)**	WH/18"	20.0		
2.4	22.5	Dary gray to black, wet very loose, fine **SILTY SAND (SM)** trace clay and shell fragments	WH-1-1	22.5	2	
			WH/12"-1	25.0		
			1-1-1	27.5	2	
			WH-1-2	30.0	3	
-6.6	31.5	Boring terminated at 31.5 ft				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-15 (1 of 1) | Total Depth 11.5' | Elev: 19.8ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/13/01 | Completed: 9/13/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-2-2	0.0	4	Piezometer well, consisting of one (1) inch diameter PVC tubing and 5 foot well screen (10-slot), installed to 28.5 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 3 feet, Sure-Plug bentonite backfill in upper 3 ft to ground surface. Finished well stick-up of 2.5 ft. No water encountered during drilling or upon completion
18.9	0.9	Light brown, moist, very loose, fine CLAYEY SAND (SC) trace silt	1/12"-1	2.5		
16.3	3.5	Dark brown, moist, very loose SILT (ML) trace fine sand	1/18"	5.0		
			WOH/18"	7.5		
			WOH/18"	10.0		
8.3	11.5	Boring terminated at 11.5 feet				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

BORING LOG

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-16** (1 of 1) Total Depth **11.5'** Elev: **19.0ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/13/01** Completed: **9/13/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	WH-1-1	0.0	2	Piezometer well, consisting of one (1) inch diameter PVC tubing and 5 foot well screen (10-slot), installed to 10 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 3.1 feet, Sure-Plug bentonite backfill in upper 3.1 ft to ground surface. Finished well stick-up of 3.0 ft. No water encountered during drilling or upon completion.
18.1	0.9	Brown, moist, very loose fine **SILTY SAND (SM)** trace roots	WH-1-1	2.5	2	
16.0	3.0	Dark brown and dark gray moist, very soft **CLAYEY SILT (ML)** trace fine sand	WH/12"-1	5.0		
			WH/18"	7.5		
			WH/18"	10.0		
7.5	11.5	Boring terminated at 11.5 ft				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-17 (1 of 1) | Total Depth 11.5' | Elev: 19.1ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/13/01 | Completed: 9/13/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-1/2"	0.0		
17.6	1.5	Dark gray to black, moist, very loose SILT (ML) trace fine sand	1/12"-1	2.5		
			1/18"	5.0		No water encountered during drilling or upon completion above the cave-in at 3.8 feet
			WH/18"	7.5		
			WH/18"	10.0		
7.6	11.5	Boring terminated at 11.5 feet				
						*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.			
Project: South Cell Restoration, Hart-Miller Island, Maryland			
Boring No.: B-18 (1 of 1)	Total Depth 11.5'	Elev: 18.5ft ± *	Location: See Boring Location Plan
Type of Boring: HSA	Started: 9/13/01	Completed: 9/13/01	Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-1-1	0.0	2	
17.6	0.9	Dark gray, moist, very loose, fine SANDY SILT (ML)				
			WH/12"-1	2.5		
			WH/12"-1	5.0		
			WH/18"	7.5		
			WH/18"	10.0		No water encountered during drilling or upon completion
7.0	11.5	Boring terminated at 11.5 feet				
						*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-19 (1 of 1) | Total Depth 11.5' | Elev: 19.1ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/13/01 | Completed: 9/13/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1/12"-1	0.0		
17.9	1.2	Black, moist to wet, very loose, fine SANDY SILT (ML)	4-1/18"	2.5		
			WH/18"	5.0		
			9-WH/18"	7.5		No water encountered during drilling or upon completion about the cave-in at 3.8 feet
			WH/18"	10.0		
7.6	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-1

El: 18.5 (Note)

PROJECT No. : 98-035

ELEV

HAMMER : 140 Lbs

BORING METHOD : HSA

DATE START : 2/27/98

HAMMER DROP : 30 In.

ROCK CORE DIA. :

FINISH : 2/27/98

SPOON O.D. : 2 In.

FOREMAN : K. Calendar

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Gray Brown Silty CLAY		0	S-1	1 - 2 - 3 - 3	DS	6"	
			5	S-2	1 - 1 - 2 - 2	DS	8"	
				S-3	PUSH	ST	24"	
			10	S-4	WOH	DS	18"	
			15	S-5	WOH	DS	18"	
				S-6	WOH	DS	18"	
		20.0	20	S-7	PUSH	ST	24"	
	Bottom of Boring at 20.0 feet							

LEGEND

- DS DRIVEN SPOON
- ST SHELBY TUBE
- PS PISTON SAMPLE
- RC ROCK CORE
- HSA HOLLOW STEM AUGER
- DC DRIVEN CASING
- MD MUD DRILLING

GROUND WATER

WATER ON RODS : NONE

AT COMPLETION : 1.5 feet

AT Hours WATER :

CAVED : 5.0 feet

CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Ce Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-2
El: 18.3 (Note)
PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD: DC-4 in.

DATE START : 2/27/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 2/27/98
SPOON O.D. : 2 In.

FOREMAN : J. Sies

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Brown-Gray Silty CLAY		0	S-1	1 - 2 - 2 - 2	DS	6"	
								Encountered water @ 3 ft.
		5.0	5	S-2	1 - 1 - 1 - 1	DS	6"	
	Gray Silty CLAY							Drill rods dropped from 6' to 12.5 ft No resistance
			10					
				S-3	WOH	DS	12"	
			15					
				S-4	WOH	DS	24"	
				S-5	PUSH	ST	20"	
	Bottom of Boring at 20.0 feet	20.0	20					

LEGEND
- DS DRIVEN SPOON
- ST SHELBY TUBE
- PS PISTON SAMPLE
- RC ROCK CORE
- HSA HOLLOW STEM AUGER
- DC DRIVEN CASING
- MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 1.8 feet
AT Hours
WATER :

CAVED : 7.0 feet
CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-3
El: 21.1 (Note)
PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : HSA

DATE START : 2/27/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 2/27/98
SPOON O.D. : 2 In.
FOREMAN : K. Calendar

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 In	TYPE	REC	NOTES
	Gray Silty CLAY		0	S-1	2 - 2 - 2 - 2	DS	18"	
				S-2	2 - 1 - 2 - 3	DS	12"	
			5	S-3	WOH	DS	18"	
			10	S-4	1 - 2 - 1 - 1	DS	12"	
				S-5	2 - 1 - 3 - 1	DS	12"	
			15	S-6	2 - 2 - 1 - 2	DS	14"	
				S-7	PUSH	ST	24"	
	Bottom of Boring at 20.0 feet	20.0	20					

LEGEND
- DS DRIVEN SPOON
- ST SHELBY TUBE
- PS PISTON SAMPLE
- RC ROCK CORE
- HSA HOLLOW STEM AUGER
- DC DRIVEN CASING
- MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 7.0 feet
CAVED : 10.0 feet
AT WATER : Hours
CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-4
El: 19.6 (Note)
PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : HSA

DATE START : 3/4/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/4/98
SPOON O.D. : 2 In.

FOREMAN : K. Calendar

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		0	S-1	2 - 2 - 4 - 4	DS	16"	
				S-2	1 - 1 - 1 - 1	DS	4"	
			5					Installed 2" PVC well
				S-3	WOH	DS	18"	Bottom of well 15' - 10' screen
								Sand Pack 3' - 15'
								Bentonite seal 1' - 3'
			10					Grout 0' - 1'
				S-4	WOH	DS	12"	2 ft. stick up
								Backfill boring w/ sand 15' - 30'
				S-5	1 - 1 - 1 - 2	DS	18"	
			15					
				S-6	2 - 2 - 4 - 5	DS	18"	
			20					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION :
AT Hours
WATER :

CAVED :

CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Ce
Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

BORING No.: B-4
El: 19.6 (Note)
PROJECT No.: 98-035

PROJECT: Hart Miller Island South Cell Restoration
Location: As Staked

ELEV:
HAMMER: 140 Lbs
BORING METHOD: HSA

DATE START: 3/4/98
HAMMER DROP: 30 In.
ROCK CORE DIA.:

FINISH: 9/4/98
SPOON O.D.: 2 In.

FOREMAN: K. Calendar

ELEV.	DESCRIPTION	DEPTH	SCALE	NO.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		20					
			25	S-7	6 - 8 - 8 - 10	DS	18"	
				S-8	6 - 8 - 10 - 12	DS	18"	
		30.0	30	S-9	10 - 12 - 9 - 11	DS	18"	
	Bottom of Boring at 30.0 feet							
			35					
			40					

LEGEND
- DS DRIVEN SPOON
- ST SHELBY TUBE
- PS PISTON SAMPLE
- RC ROCK CORE
- HSA HOLLOW STEM AUGER
- DC DRIVEN CASING
- MD MUD DRILLING

GROUND WATER
WATER ON RODS: NONE
AT COMPLETION:
AT Hours
WATER:

CAVED:

CAVED:

Note: Elevation added by F&R, February 2002, based on survey data given on South C Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-5
El: 19.0(Note)
PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : DC-4 in.

DATE START : 3/2/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/2/98
SPOON O.D. : 2 In.

FOREMAN : J. Sies

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Brown Silty CLAY		0	S-1	1 - 2 - 2 - 2	DS	6"	
		2.0						
	Gray Silty CLAY			S-2	WOH	DS	24"	Installed 2" PVC Well
			5					
				S-3	WOH	DS	24"	Bottom of well 28' - 10' screen Sand Pack 16'-28' Bentonite seal 14' - 16'
			10					Grout 0 - 14'
				S-4	WOH	DS	24"	2 ft. stick up
				S-5	WOH	DS	24"	
			15					
				S-6	WOH	DS	24"	
			20					

LEGEND

DS	DRIVEN SPOON
ST	SHELBY TUBE
PS	PISTON SAMPLE
RC	ROCK CORE
HSA	HOLLOW STEM AUGER
DC	DRIVEN CASING
MD	MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 3.0 feet CAVED :
AT WATER : Hours CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cel Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-5
El: 19.0 (Note)
PROJECT No. : 98-035

ELEV :
HAMMER : 140 Lbs
BORING METHOD : DC-4 in.

DATE START : 3/2/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/2/98
SPOON O.D. : 2 In.

FOREMAN : J. Sies

ELEV.	DESCRIPTION	DEPTH	SCALE	NO.	Blows / 6 In	TYPE	REC	NOTES
	Gray Silty CLAY		20					
				S-7	WOH	DS	24"	
			25					
				S-8	WOH	DS	24"	
				S-9	WOH	DS	24"	
		30.0	30					
	Bottom of Boring at 30.0 feet							
			35					
			40					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 3.0 feet
CAVED :
AT Hours
WATER :
CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-6
El: 19.8 (Note)

PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : DC-4 in.

DATE START : 3/5/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/5/98
SPOON O.D. : 2 In.

FOREMAN : J. Sies

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Red-Brown Silty CLAY, some roots		0					
				S-1	1 - 1 - 1 - 1	DS	5"	
				S-2	1 - 1 - 1 - 1	DS	4"	
		5.0	5					Installed 2" PVC Well
	Gray Silty CLAY			S-3	WOH	DS	24"	Bottom of well 15'- 10' screen
								Sand Pack 3'- 5'
								Bentonite seal 1'- 3'
			10					Grout 0'- 1'
				S-4	WOH	DS	12"	2 ft. stick up
								Backfilled boring w/ sand 15'- 30'
				S-5	WOH	DS	24"	
			15					
				S-6	WOH	DS	24"	
			20					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 0.6 feet CAVED :
AT Hours
WATER : CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

BORING No. : B-6
El: 19.8 (Note)
PROJECT No. : 98-035

ROJECT : Hart Miller Island
South Cell Restoration
ocation : As Staked

ELEV :
HAMMER : 140 Lbs
DRING METHOD : DC-4 in.
DATE START : 3/5/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :
FINISH : 3/5/98
SPOON O.D. : 2 In.
FOREMAN : J. Sies

LEV.	DESCRIPTION	DEPTH	SCALE	NO.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		20					
				S-7	WOH	DS	24"	
			25					
				S-8	WOH	DS	24"	
				S-9	PUSH	ST	14"	
		30.0	30					
	Bottom of Boring at 30.0 feet							
			35					
			40					

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 0.6 feet
AT Hours
WATER :
CAVED :
CAVED :

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : As Staked

BORING No. : B-7
El: 31.1 (Note)

PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : HSA

DATE START : 3/2/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/2/98
SPOON O.D. : 2 In.

FOREMAN : K. Calendar

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 In	TYPE	REC	NOTES
	Gray Silty CLAY		0					
				S-1	2 - 1 - 1 - 1	DS	18"	
			5	S-2	1 - 1 - 1 - 1	DS	4"	
				S-3	PUSH	PT	24"	
			10	S-4	WOH	DS	16"	
			15	S-5	WOH	DS	18"	
				S-6	WOH	DS	18"	
		20.0	20	S-7	WOH	DS	18"	
	Bottom of Boring at 20.0 feet							

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 2.1 feet CAVED : 6.5 feet
AT Hours
WATER : CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Cell Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island South Cell Restoration

Location : As Staked

BORING No. : B-8

El: 18.4(Note)

PROJECT No. : 98-035

ELEV

HAMMER : 140 Lbs

BORING METHOD : HSA

DATE START : 3/2/98

HAMMER DROP : 30 In.

ROCK CORE DIA. :

FINISH : 3/2/98

SPOON O.D. : 2 In.

FOREMAN : K. Calendar

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		0	S-1	1 - 1 - 1 - 1	DS	18"	
			5	S-2	WOH	DS	18"	
				S-3	PUSH	ST	24"	
			10	S-4	WOH	DS	14"	
			15	S-5	WOH	DS	18"	
				S-6	WOH	DS	18"	
		20.0	20	S-7	PUSH	ST	24"	
	Bottom of Boring at 20.0 feet							

LEGEND

DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER

WATER ON RODS : NONE

AT COMPLETION : 1.0 feet CAVED : 4.1 feet

AT Hours WATER : CAVED :

Note: Elevation added by F&R, February 2002, based on survey data given on South Ce Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration

Location : Offset boring 600 ft. south from stake location

BORING No. : B-9
El: (Note)
PROJECT No. : 98-035

ELEV
HAMMER : 140 Lbs
BORING METHOD : DC-4 in.

DATE START : 3/4/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/4/98
SPOON O.D. : 2 In.

FOREMAN : J. Sies

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Brown-Gray Silty CLAY, trace roots		0	S-1	1 - 1 - 1 - 1	DS	6"	Drill rods dropped from 6' to 14'
		3.0						
	Gray Silty CLAY		5	S-2	1 - 1 - 1 - 1	DS	12"	Took sample 14' - 16'
								Rods dropped to 21.5'
								Installed 2" PVC Well
								Bottom of well at 15' - 10' screen
			10					Sand pack 3' - 15'
								Bentonite seal 1' - 3'
								Grout 0' - 1'
								2 ft. stick up
								Backfilled boring w/ sand 23.5' - 15'
			15	S-3	WOH	DS	6"	
			20					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 4.2 feet CAVED : 4.5 feet
AT Hours
WATER : CAVED :

Note: No elevation data available

Earth Engineering & Sciences, Inc.

Boring Log

PROJECT : Hart Miller Island
South Cell Restoration
Location : Offset boring 600 ft. south from stake location

BORING No. : B-9
El : (Note)
PROJECT No. : 98-035

ELEV :
HAMMER : 140 Lbs
BORING METHOD : DC-4 in.

DATE START : 3/4/98
HAMMER DROP : 30 In.
ROCK CORE DIA. :

FINISH : 3/4/98
SPOON O.D. : 2 In.
FOREMAN : J. Sies

ELEV.	DESCRIPTION	DEPTH	SCALE	NO.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		20					
				S-4	WOH	DS	24"	
	Bottom of Boring at 23.5 feet	23.5						
			25					
			30					
			35					
			40					

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 4.2 feet CAVED : 4.5 feet
AT Hours
WATER : CAVED :

Note: No elevation data available

Earth Engineering & Sciences, Inc.

Boring Log

BORING No. : B-10
El: 18.8 (Note)
PROJECT No. : 98-035

PROJECT : Hart Miller Island
South Cell Restoration

Location : Offset boring 600 ft. south from stake location

ELEV
DATE START : 3/4/98
FINISH : 3/4/98
HAMMER : 140 Lbs
HAMMER DROP : 30 In.
SPOON O.D. : 2 In.
FOREMAN : J. Sies
BORING METHOD : DC-4 in.
ROCK CORE DIA :

ELEV	DESCRIPTION	DEPTH	SCALE	No.	Blows / 6 in	TYPE	REC	NOTES
	Gray Silty CLAY		0	S-1	WOH	DS	5"	
			5	S-2	WOH	DS	12"	
				S-3	PUSH	ST	24"	
			10	S-4	WOH	DS	24"	
			15	S-5	WOH	DS	24"	
				S-6	WOH	DS	24"	
		20.0	20	S-7	WOH	DS	24"	
	Bottom of Boring at 20.0 feet							

GROUND WATER
WATER ON RODS : NONE
AT COMPLETION : 3.0 feet
CAVED : 7.2 feet
AT WATER : Hours
CAVED :

LEGEND
DS DRIVEN SPOON
ST SHELBY TUBE
PS PISTON SAMPLE
RC ROCK CORE
HSA HOLLOW STEM AUGER
DC DRIVEN CASING
MD MUD DRILLING

Note: Elevation added by F&R, February 2002, based on survey data given on South Ce
Boring Locations drawing by U.S. Army Corps of Engineers Baltimore District.

Appendix IV

LABORATORY TEST RESULTS

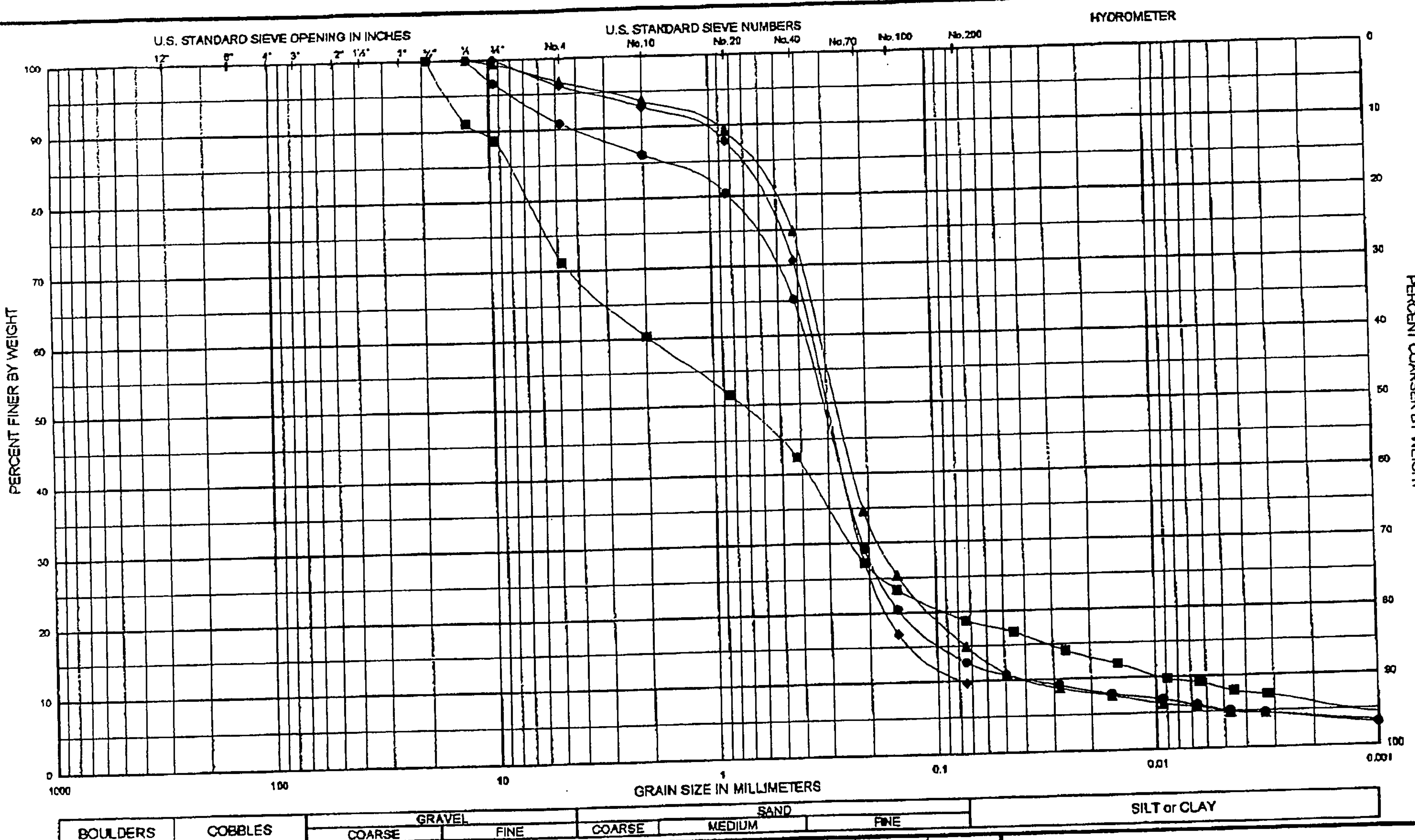
DATE: Nov.2001

PROJECT: Hart-Miller Island
South Cell Restoration
AREA: Baltimore County, MD

TEST: Natural Moisture Contents (ASTM D 2216) & Atterberg Limits (ASTM D 4318)

Hole No.	Sample No.	Depth (ft.)	Moisture Content, %	LL	PL	PI	Classification	Symbol
B-1	Jar-2	2.5-4.0	3.6		N.P.		Silt	(ML)
B-1	Jar-4	7.5-9.0	7.1		N.P.		Silt	(ML)
B-1	Jar-5	10.0-11.5	5.5		N.P.		Silt	(ML)
B-1	Jar-6	12.5-14.0	5.4		N.P.		Silt	(ML)
B-1	Jar-7	15.0-16.5	4.4		N.P.		Silt	(ML)
B-1	Jar-8	17.5-19.0	6.2		N.P.		Silt	(ML)
B-1	Jar-9	20.0-21.5	3.8		N.P.		Silt	(ML)
B-1	Jar-10	22.5-24.0	8.1		N.P.		Silt	(ML)
B-1	Jar-11	25.0-26.5	5.4		N.P.		Silt	(ML)
B-1	Jar-12	27.5-29.0	13.1		N.P.		Silt	(ML)
B-2	Jar-2	2.5-4.0	82.8	114	41	73	Fat clay	(CH)
B-3	Jar-2	2.5-4.0	48.4	101	46	55	Elastic silt	(MH)
B-9	Jar-2	2.5-4.0	9.8		N.P.		Silt	(ML)
B-9	Jar-3	5.0-6.5	8.4		N.P.		Silt	(ML)
B-9	Jar-4	7.5-9.0	9.3	23	17	6	Silty clay	(CL-ML)
B-10	Jar-5	10.0-11.5	26.6		N.P.		Silt	(ML)
B-10	Jar-11	25.0-26.5	22.1	25	16	9	Lean clay	(CL)
B-11	Jar-5	10.0-11.5	52.8	69	30	39	Fat clay	(CH)
B-12	Jar-3	5.0-6.5	69.3	97	39	58	Fat clay	(CH)
B-12	Jar-10	22.5-24.0	22.5		N.P.		Silt	(ML)
B-13	Jar-2	2.5-4.0	6.6	18	15	3	Silt	(ML)
B-13	Jar-3	5.0-6.5	17.4		N.P.		Silt	(ML)
B-13	Jar-4	7.5-9.0	19.5		N.P.		Silt	(ML)
B-13	Jar-5	10.0-11.5	24.3		N.P.		Silt	(ML)
B-13	Jar-6	12.5-14.0	21.3		N.P.		Silt	(ML)
B-13	Jar-7	15.0-16.5	21.6		N.P.		Silt	(ML)
B-13	Jar-8	17.5-19.0	22.2		N.P.		Silt	(ML)
B-13	Jar-9	20.0-21.5	28.2	27	19	8	Lean clay	(CL)
B-13	Jar-10	22.5-24.0	23.7	27	21	6	Silty clay	(CL-ML)
B-13	Jar-11	25.0-26.5	23.0	30	21	9	Lean clay	(CL)
B-13	Jar-12	27.5-29.0	23.4		N.P.		Silt	(ML)
B-14	Jar-3	5.0-6.5	100.8	131	46	85	Fat clay	(CH)
B-15	Jar-2	2.5-4.0	74.7	104	39	65	Fat clay	(CH)
B-15	Jar-4	7.5-9.0	92.3	97	36	61	Fat clay	(CH)
B-17	Jar-2	2.5-4.0	78.5	97	33	64	Fat clay	(CH)

Note: The Atterberg Limits test is only performed on minus No. 40 material portion of a sample and does not represent the entire sample. Refer to the Visual Classification or the Gradation Analysis for the complete classification.

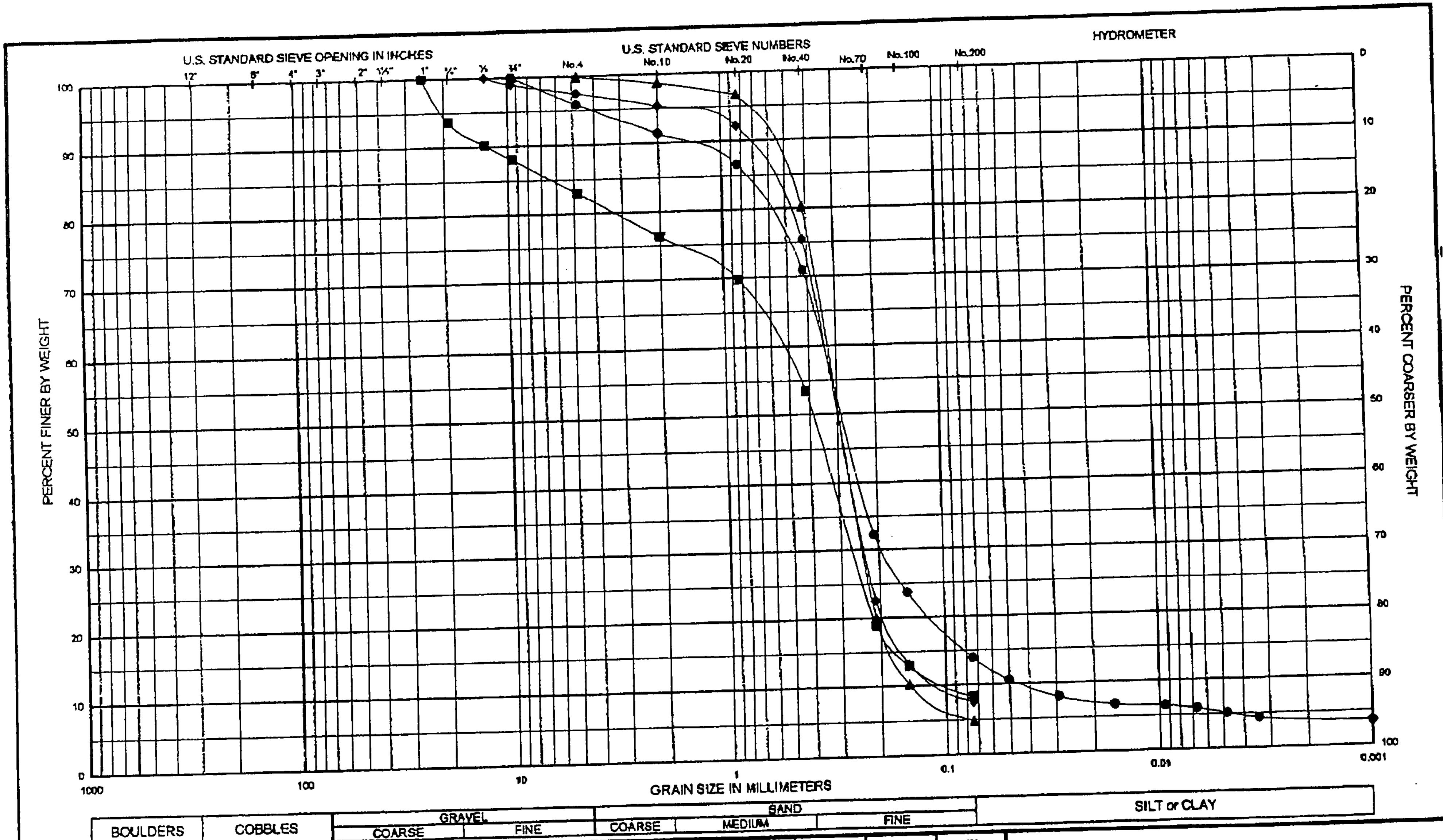


Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-1	0.0-1.5	Silty sand with gravel	(SM)	——	——	——	——
—◆—	Jar-2	2.5-4.0	Poorly graded sand with silt (tr. gravel)	(SP-SM)	3.6		N.P.	
—▲—	Jar-3	5.0-6.5	Silty sand (tr. gravel)	(SM)	——	——	——	——
—●—	Jar-4	7.5-9.0	Silty sand (tr. gravel)	(SM)	7.1		N.P.	

GRADATION CURVES (Sieve Analysis: ASTM D422)

ENG FORM 2087

PROJECT:	Hart-Miller Island South Cell Restoration
AREA:	Baltimore County, MD
Boring No.:	B-1 Sht. 1 of 3
DATE:	Nov 2001



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-5	10.0-11.5	Poorly graded sand with silt and gravel	(SP-SM)	5.5		N.P.	
—◆—	Jar-6	12.5-14.0	Poorly graded sand with silt (tr. gravel)	(SP-SM)	5.4		N.P.	
—▲—	Jar-7	15.0-16.5	Poorly graded sand	(SP)	4.4		N.P.	
—●—	Jar-8	17.5-19.0	Silty sand (tr. gravel)	(SM)	6.2		N.P.	

GRADATION CURVES (Sieve Analysis: ASTM D422)

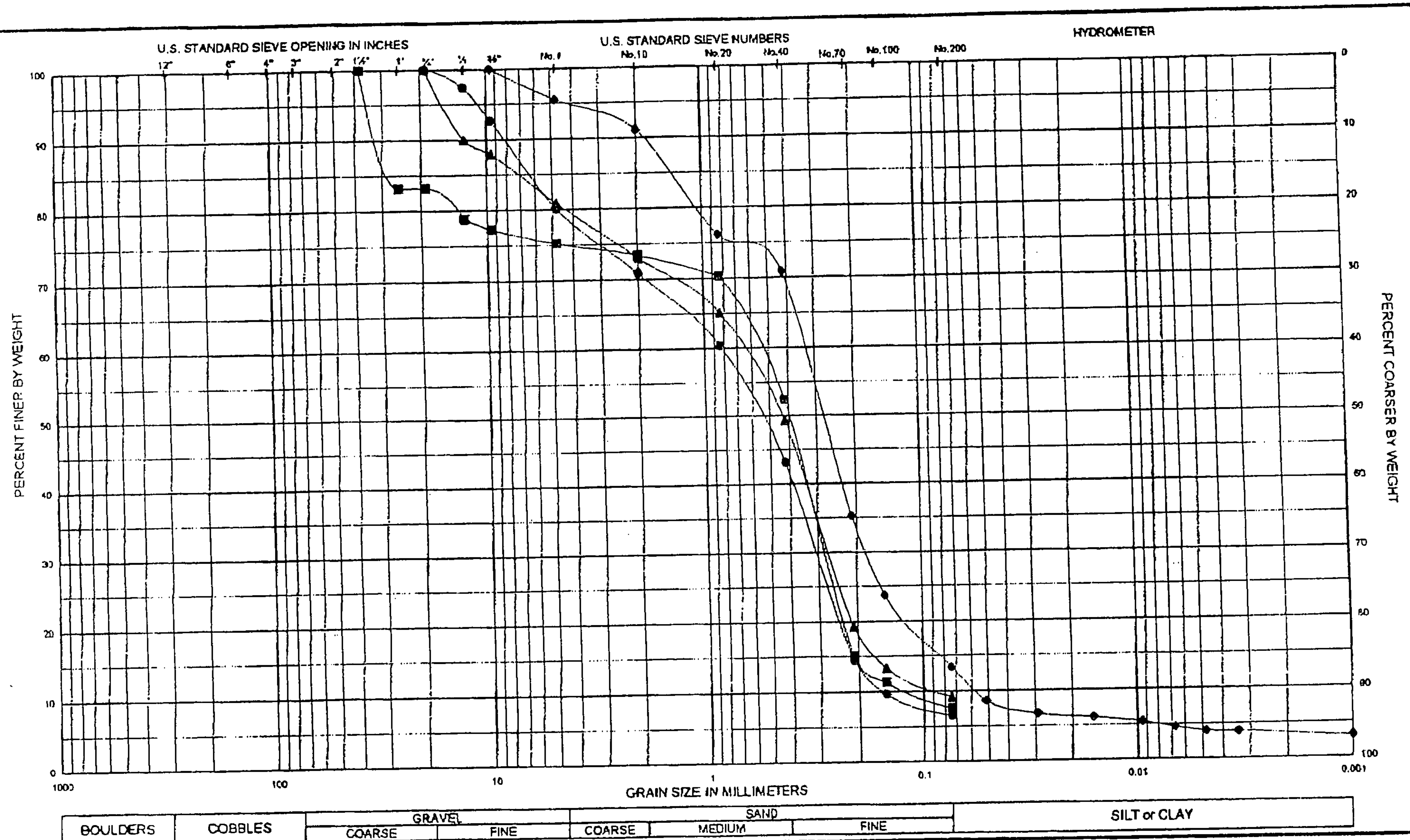
PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

Boring No.: B-1 Sht. 2 of 3

DATE: Nov 2001

ENG FORM 2087



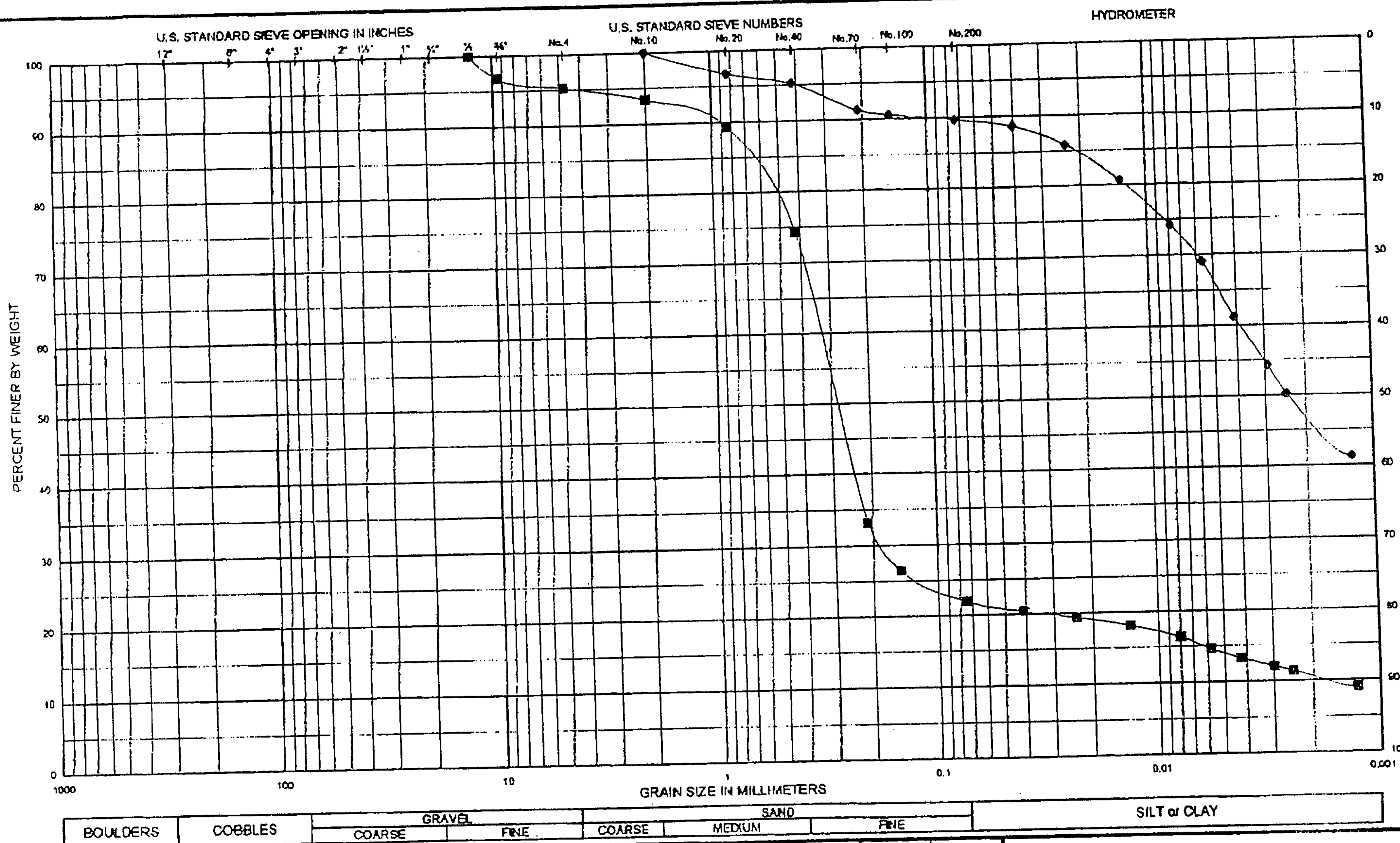
Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-9	20.0-21.5	Poorly graded sand with silt and gravel	(SP-SM)	3.8		N.P.	
—◆—	Jar-10	22.5-24.0	Silty sand (tr. gravel)	(SM)	8.1		N.P.	
—▲—	Jar-11	25.0-26.5	Well-graded sand with silt and gravel	(SW-SM)	5.4		N.P.	
—●—	Jar-12	27.5-29.0	Poorly graded sand with silt and gravel	(SP-SM)	13.1		N.P.	

PROJECT:	Hart-Miller Island South Cell Restoration
AREA:	Baltimore County, MD
Boring No.:	B-1 Sht. 3 of 3
DATE:	Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-1	0.0-1.5	Silty sand (tr. gravel)	(SM)	——	——	——	——
—●—	Jar-3	5.0-6.5	Fat clay (tr. sand)	(CH)	——	——	——	——

PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

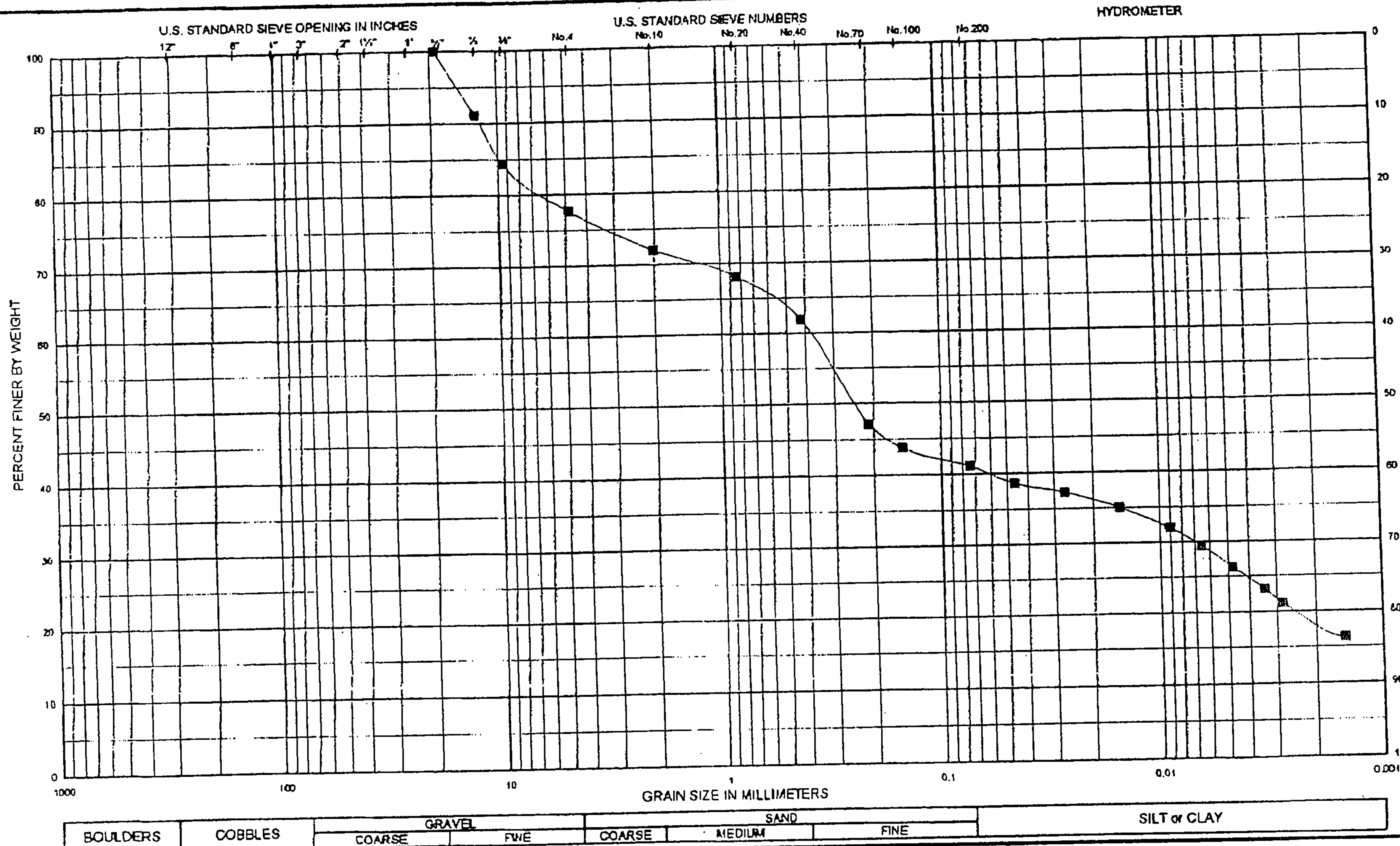
Boring No.: B-2

DATE: Nov 2001

GRADATION CURVES

(Sieve Analysis: ASTM D422)

ENG FORM 2087



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-1	0.0-1.5	Silty clayey sand with gravel (SC-SM)	—	—	—	—

PROJECT: Hart-Miller Island South Cell Restoration

AREA: Baltimore County, MD

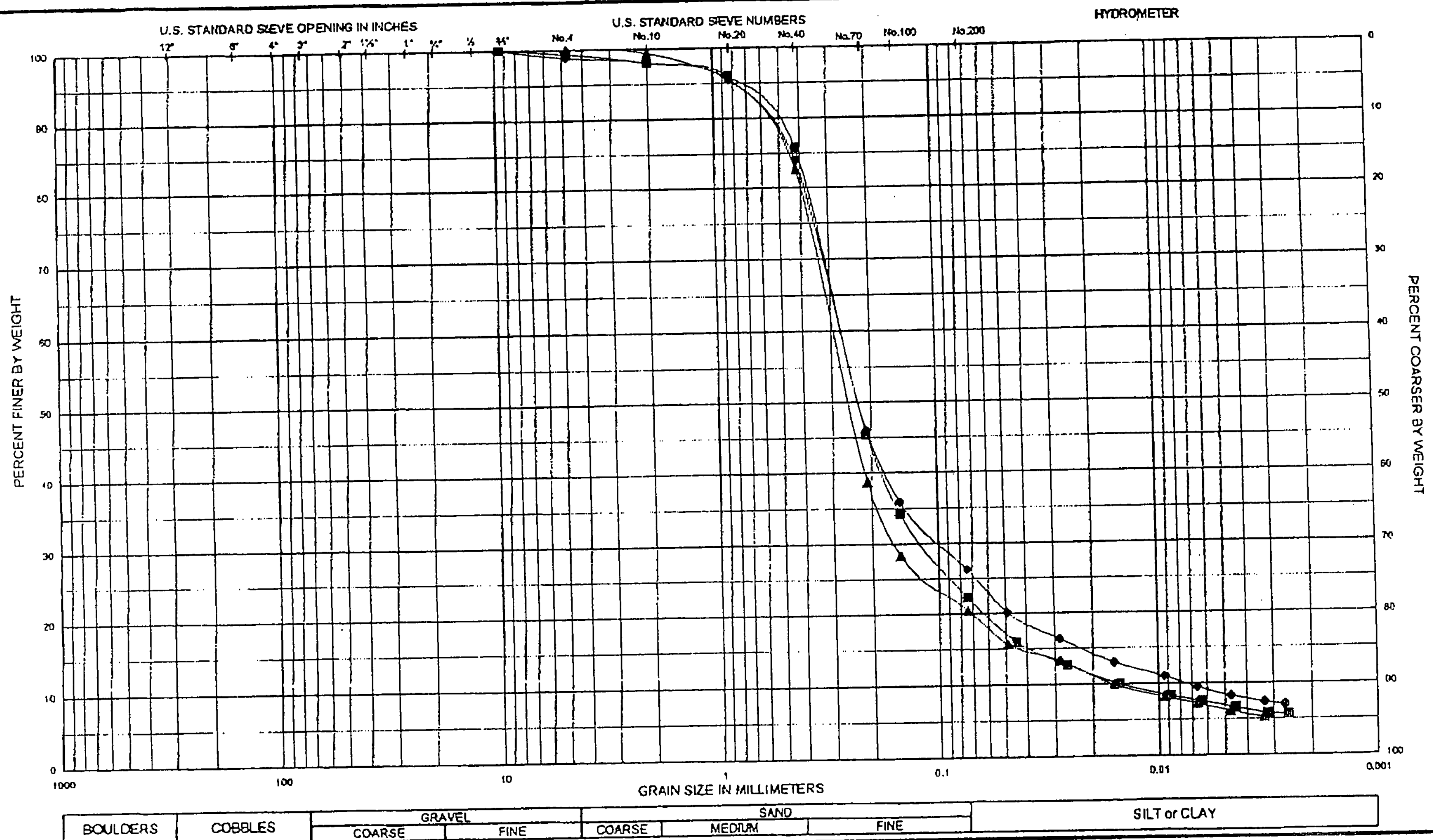
Boring No.: B-3

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-1	0.0-1.5	Silty sand	(SM)	——	——	——	——
—◆—	Jar-3	5.0-6.5	Silty sand (tr. gravel)	(SM)	8.4		N.P.	
—▲—	Jar-4	7.5-9.0	Silty clayey sand	(SC-SM)	9.3	23	17	6

PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

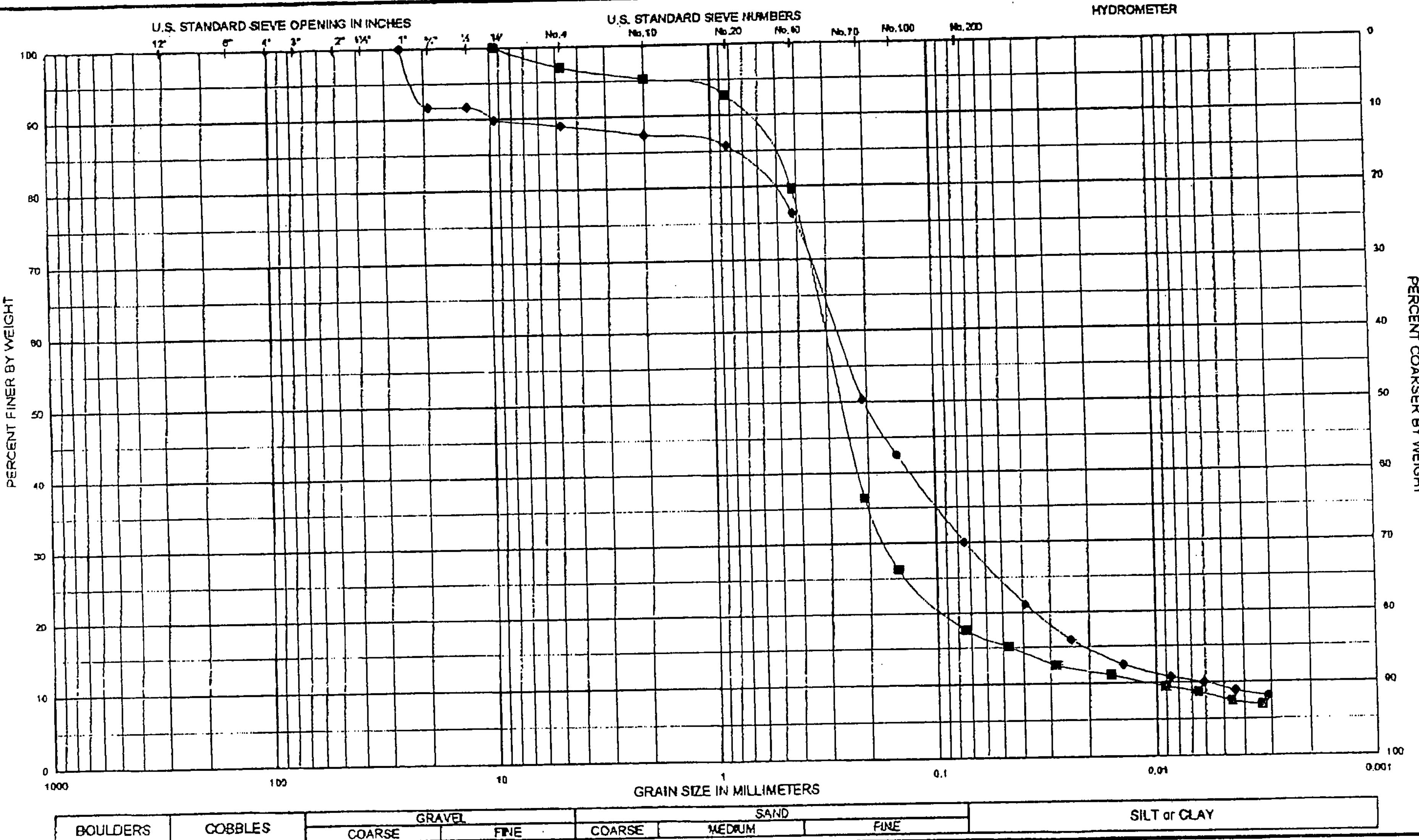
Boring No.: B-9

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-2	2.5-4.0	Silty sand (tr. gravel)	(SM)	——	——	——	——
—◆—	Jar-7	15.0-16.5	Silty sand (tr. gravel)	(SM)	——	——	——	——

PROJECT: Hart-Miller Island South Cell Restoration

AREA: Baltimore County, MD

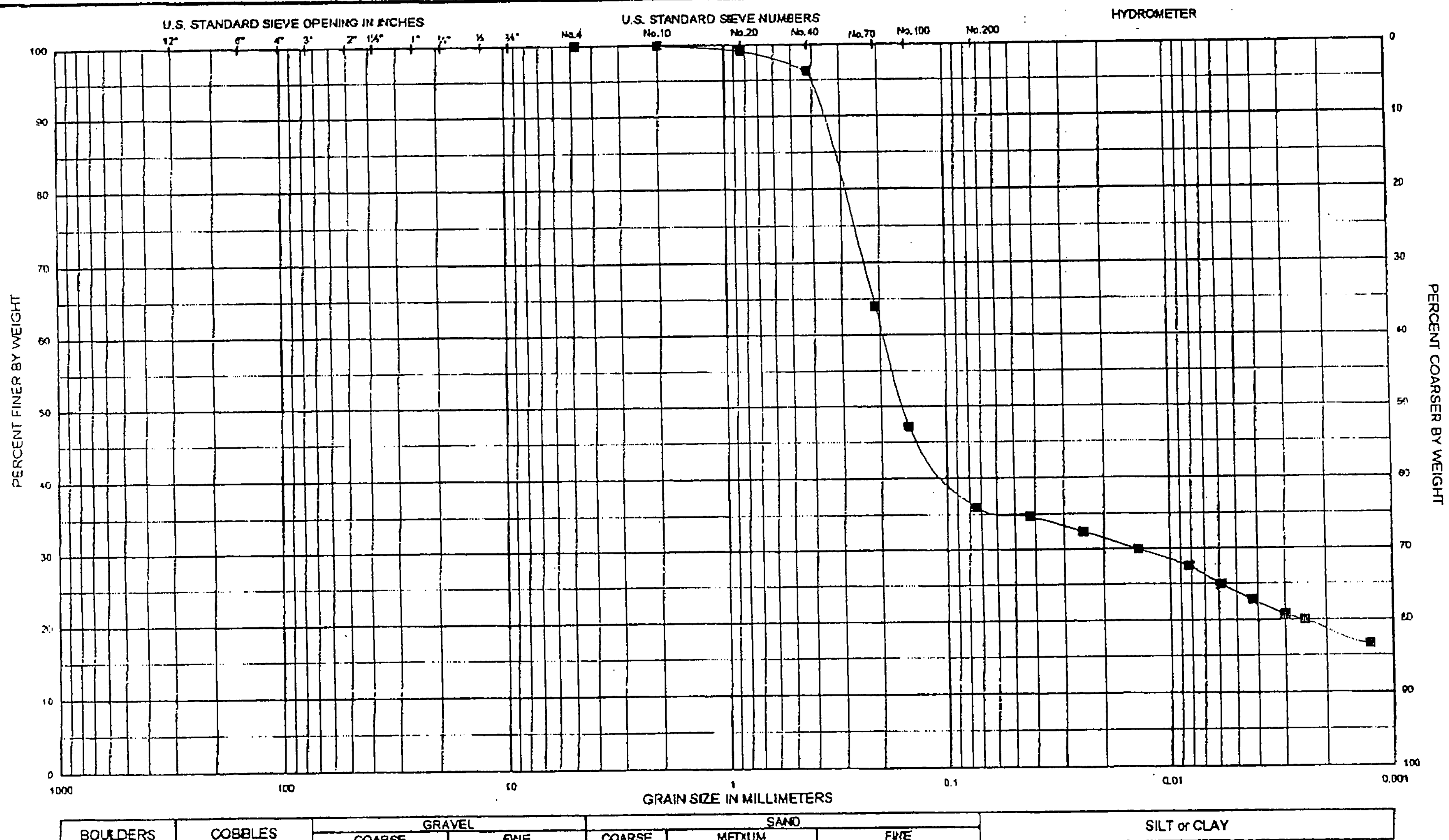
Boring No.: B-10

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-8	17.5-19.0	Silty sand (SM)	——	——	——	——

PROJECT: Hart-Miller Island South Cell Restoration

AREA: Baltimore County, MD

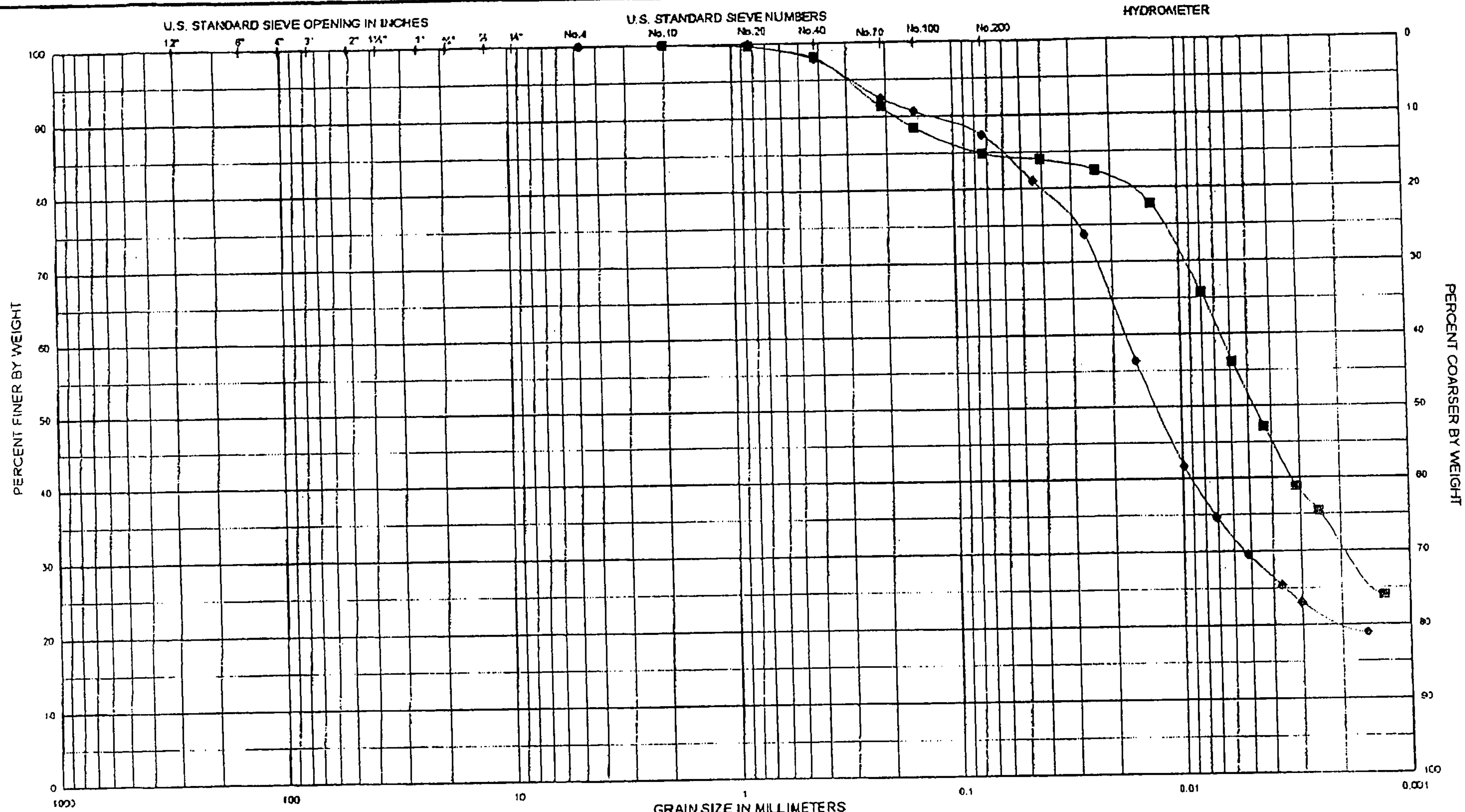
Boring No.: B-11

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



BOULDERS	COBBLES	GRAVEL		SAND			SILT or CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
	Jar-3	5.0-6.5	Fat clay with sand	(CH)	69.3	97	39	58
	Jar-11	25.0-26.5	Lean clay (tr. sand)	(CL)	—	—	—	—

PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

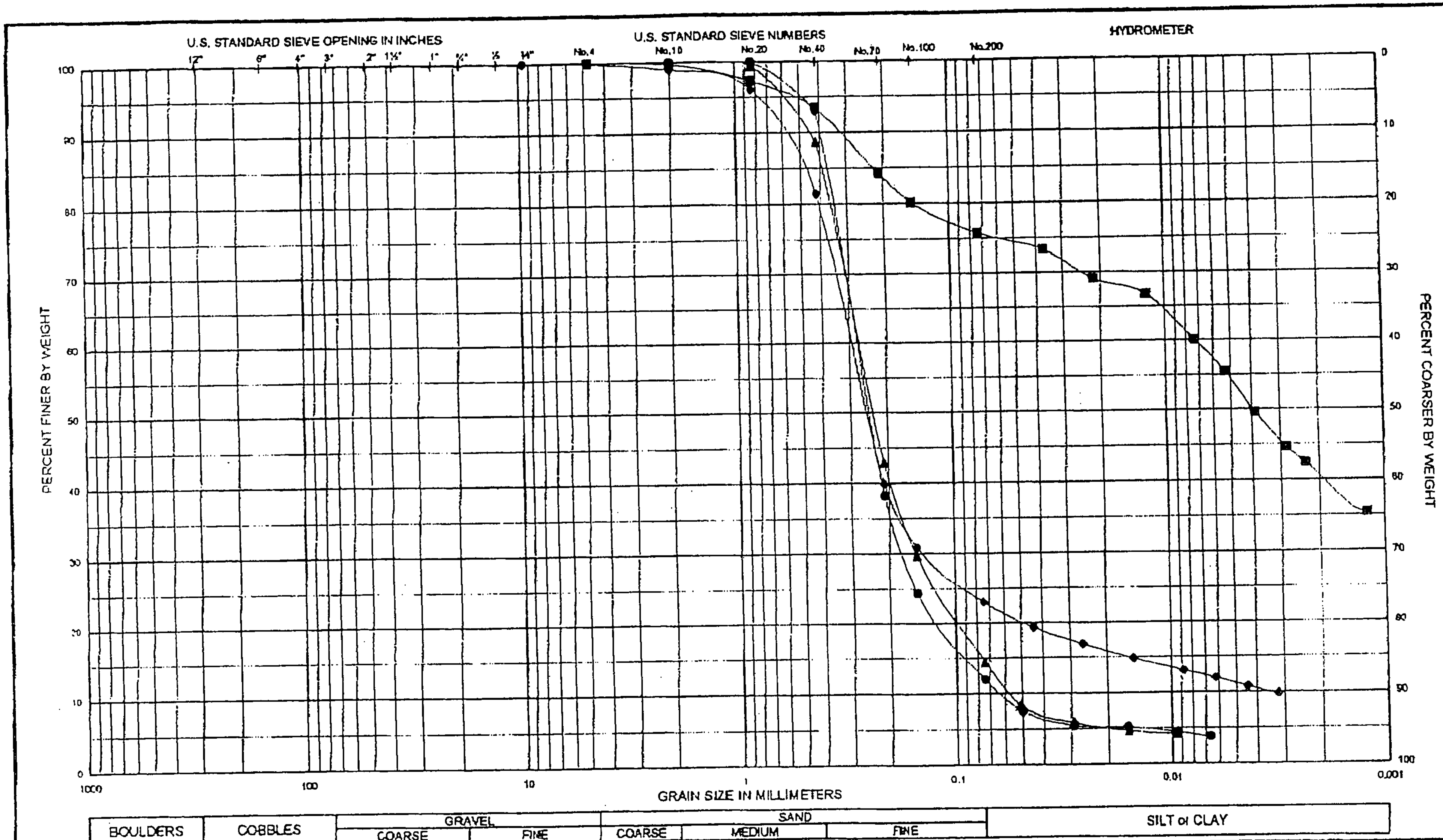
Boring No.: B-12

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
■	Jar-1	0.0-1.5	Lean clay with sand	(CL)	——	——	——	——
◆	Jar-2	2.5-4.0	Silty sand	(SM)	6.6	18	15	3
▲	Jar-3	5.0-6.5	Silty sand	(SM)	17.4		N.P.	
●	Jar-4	7.5-9.0	Poorly graded sand with silt	(SP-SM)	19.5		N.P.	

PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

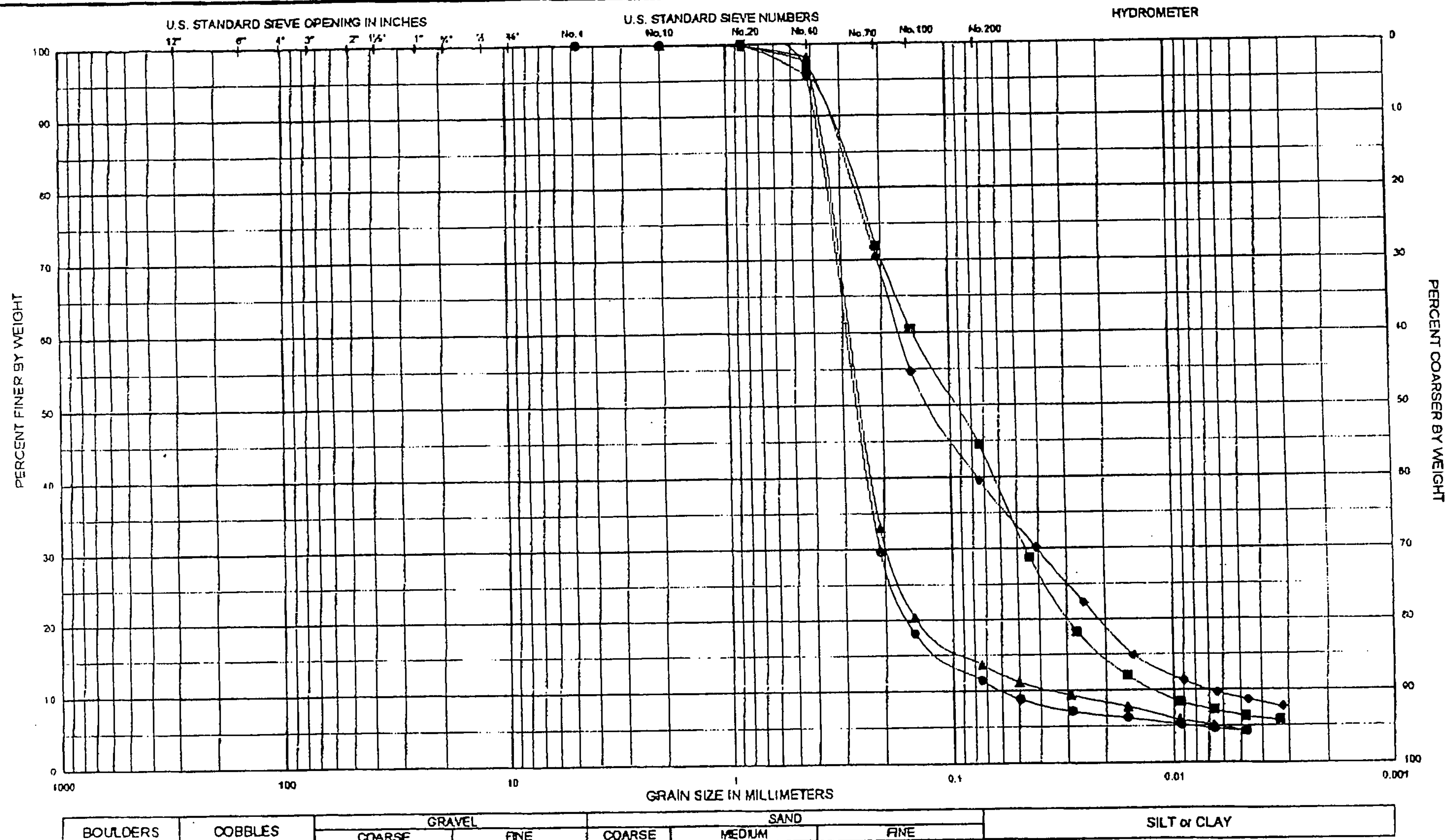
Boring No.: B-13 Sht. 1 of 3

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
■	Jar-5	10.0-11.5	Silty sand	(SM)	24.3		N.P.	
◆	Jar-6	12.5-14.0	Silty sand	(SM)	21.3		N.P.	
▲	Jar-7	15.0-16.5	Silty sand	(SM)	21.6		N.P.	
●	Jar-8	17.5-19.0	Poorly graded sand with silt	(SP-SM)	22.2		N.P.	

PROJECT: Hart-Miller Island South Cell Restoration

AREA: Baltimore County, MD

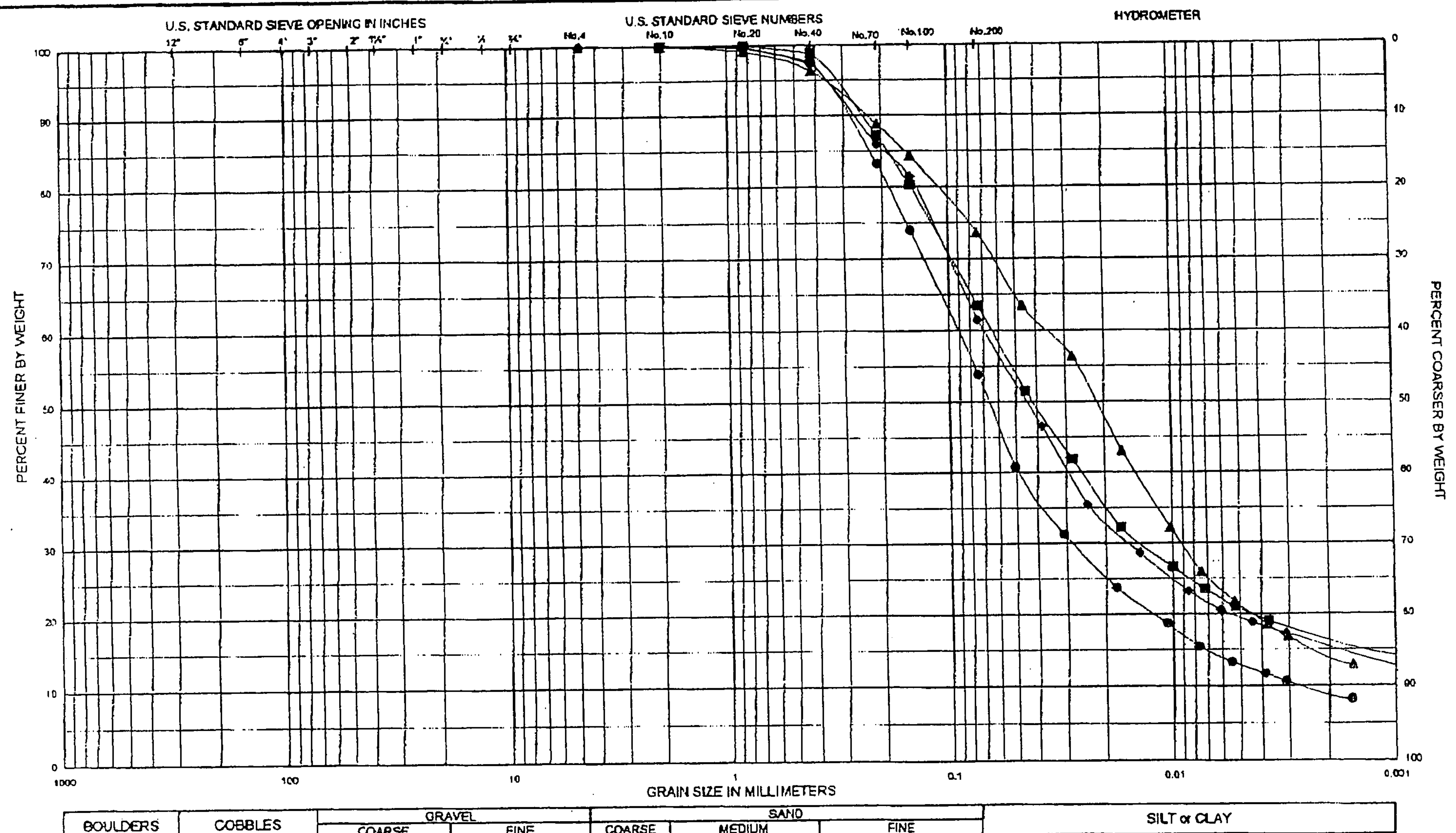
Boring No.: B-13 Sht. 2 of 3

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
■	Jar-9	20.0-21.5	Sandy lean clay	(CL)	28.2	27	19	8
◆	Jar-10	22.5-24.0	Sandy silty clay	(CL-ML)	23.7	27	21	6
▲	Jar-11	25.0-26.5	Lean clay with sand	(CL)	23.0	30	21	9
●	Jar-12	27.5-29.0	Sandy silt	(ML)	23.4		N.P.	

PROJECT: Hart-Miller Island South Cell Restoration

AREA: Baltimore County, MD

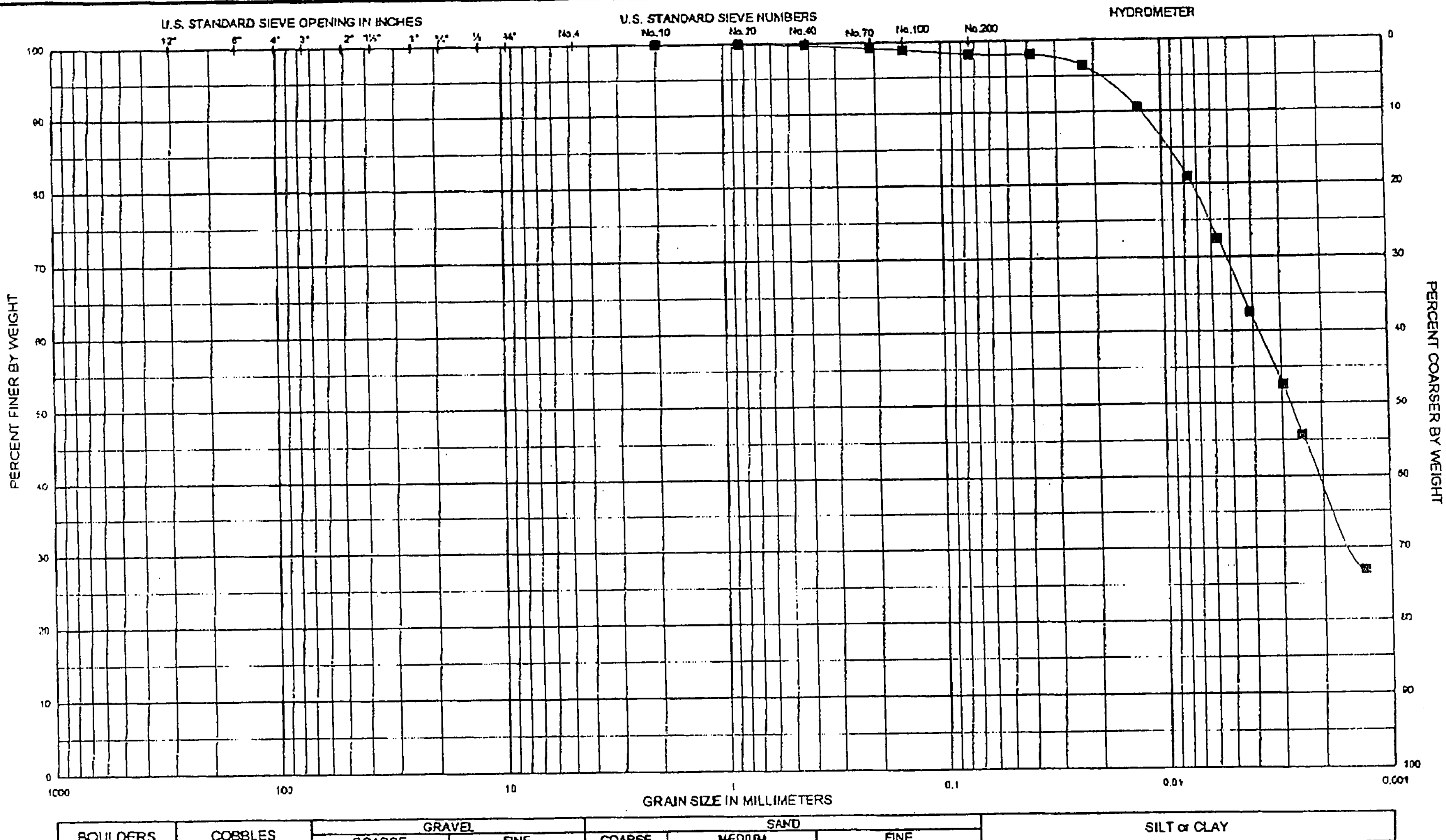
Boring No.: B-13 Sht. 3 of 3

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-5	10.0-11.5	Lean clay (tr. sand) (CL)	——	——	——	——

PROJECT: Hart-Miller Island
South Cell Restoration

AREA: Baltimore County, MD

Boring No.: B-17

DATE: Nov 2001

ENG FORM 2087

GRADATION CURVES

(Sieve Analysis: ASTM D422)

TABLE : SUMMARY OF LABORATORY TEST RESULTS

HART MILLER ISLAND

E2Si Project No. 98-035

BORING NO	SAMPLE NO	DEPTH (FEET)	NATURAL MOISTURE CONTENT,%	PH VALUE	ORGANIC CONTENT (%)	SALINITY (PPM)
B-1	-	6.0-8.0	120.4	7.58	7.3	1100
B-7	-	6.0-8.0	110.6	7.89	6.5	910
B-8	-	6.0-8.0	74.0	7.96	3.5	840
B-10	-	6.0-8.0	40.2	8.10	2.0	3100

E2Si

DIRECT SHEAR TEST

PROJECT NAME: Hart Miller Island

PROJECT NO: 98-035

LAB SAMPLE ID:

BORING NUMBER: B-3

SAMPLE NO:

DEPTH, (FT): 18-20

TEST METHOD: UU

RATE OF STRAIN: .05 IN/MIN

SATURATION:

SAMPLE DESCRIPTION: Gray Silty fine SAND, trace of Gravel & Mica

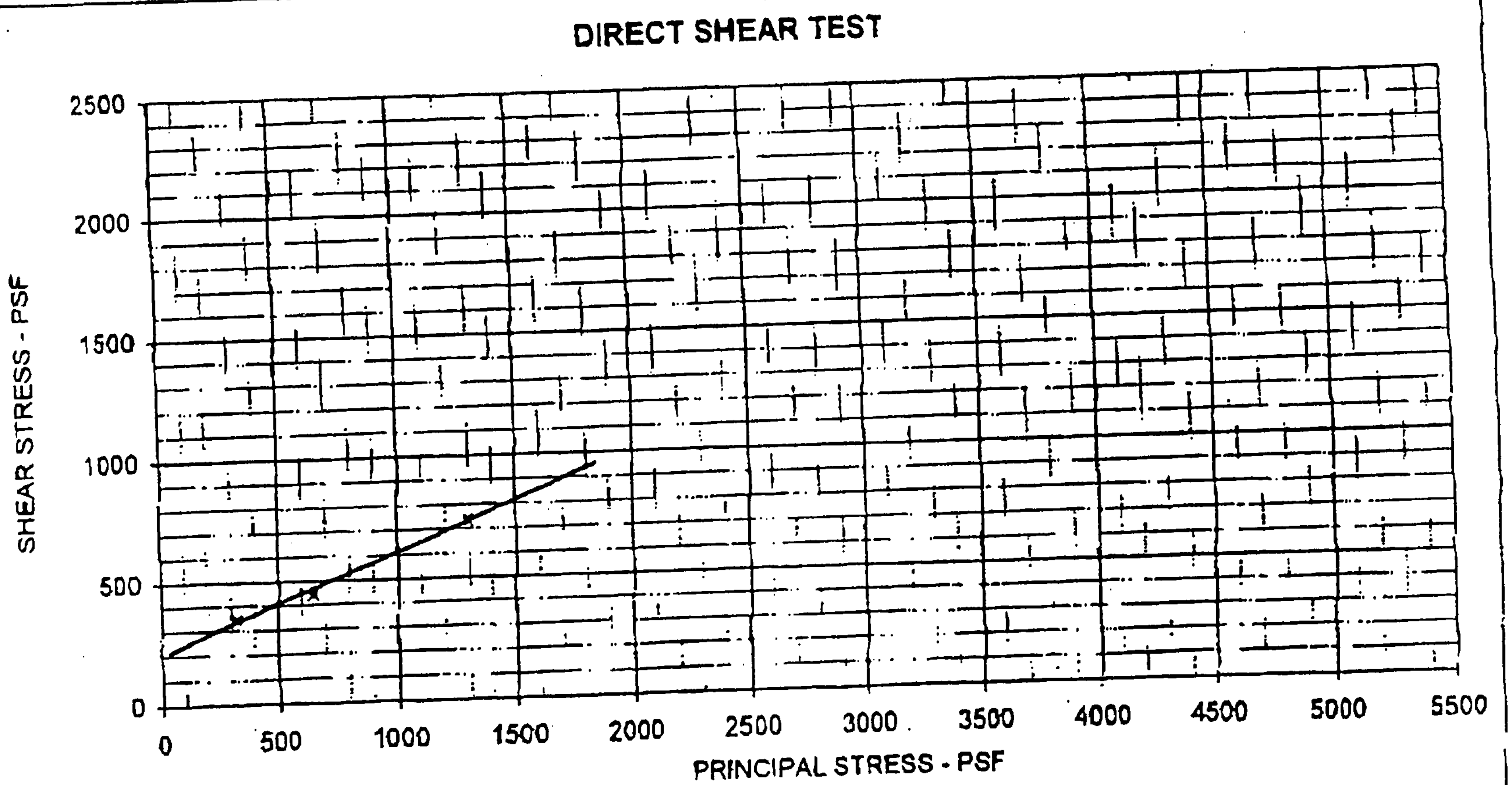
σ_3 (PSF)	DRY DENSITY (PCF)	MOISTURE %
323	98.6	23.4
646	100.1	23.3
1295	100.8	23.7

C: 200 psf

ϕ: 22^0

C':

ϕ':



E2Si

DIRECT SHEAR TEST

PROJECT NAME: Hart Miller Island

BORING NUMBER: B-6

TEST METHOD: UU

SAMPLE DESCRIPTION: Grey Silty CLAY, trace fine Sand

C: 180 psf

C':

PROJECT NO: 98-035

SAMPLE NO:

RATE OF STRAIN .05 IN/MIN

ϕ: 7°

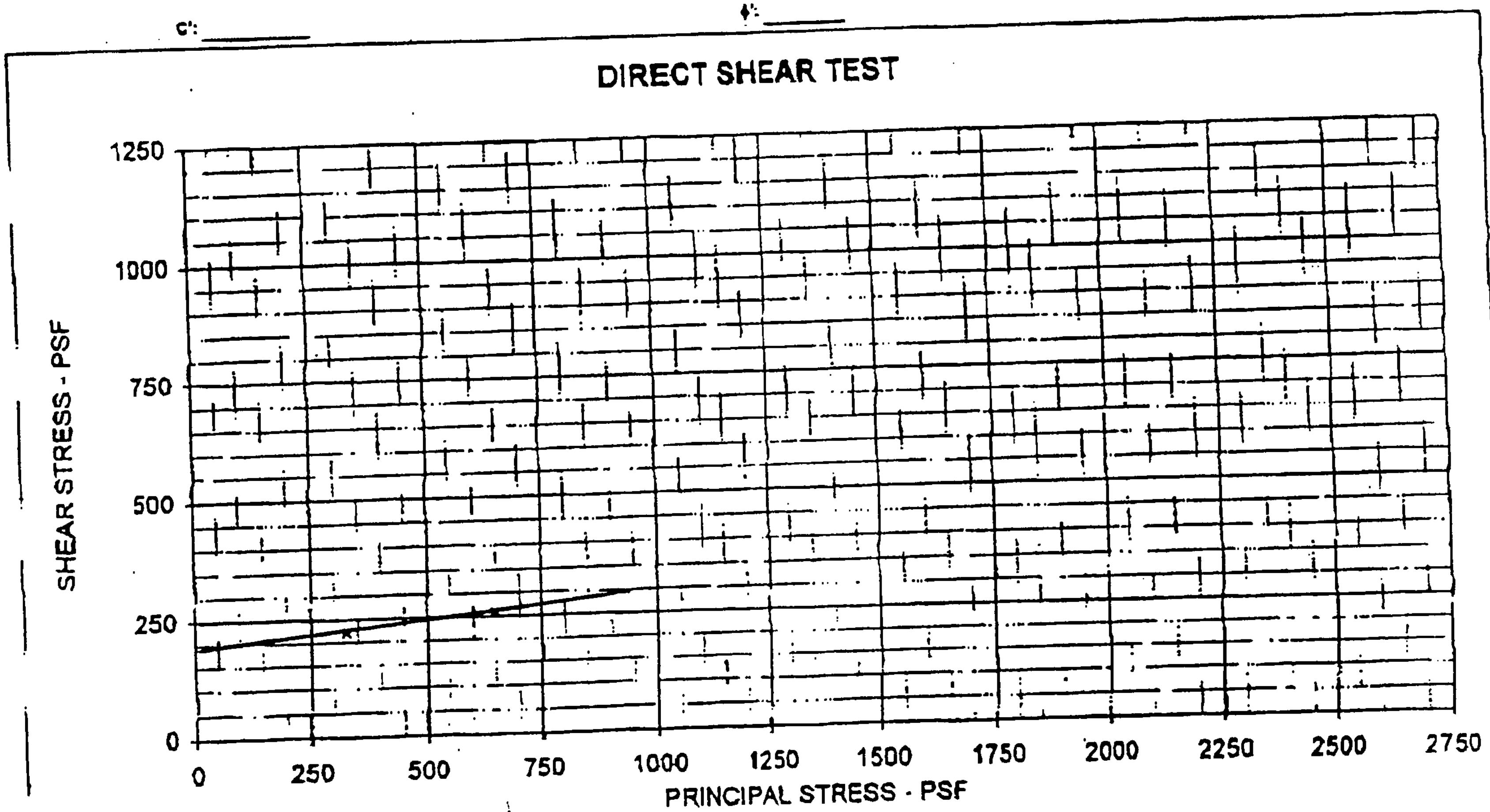
ϕ':

LAB SAMPLE ID:

DEPTH, (FT): 28-30

SATURATION:

σ_1 (PSF)	DRY DENSITY (PCF)	MOISTURE %
323	38.9	114.7
846	38.7	118.3



E2Si

DIRECT SHEAR TEST

PROJECT NAME: Hart Miller Island

BORING NUMBER: B-8

TEST METHOD: UU

SAMPLE DESCRIPTION: Gray Silty CLAY, trace fine Sand

C: 300 psf

C':

PROJECT NO: 98-035

SAMPLE NO:

RATE OF STRAIN: .05 IN/MIN

ϕ: 5°

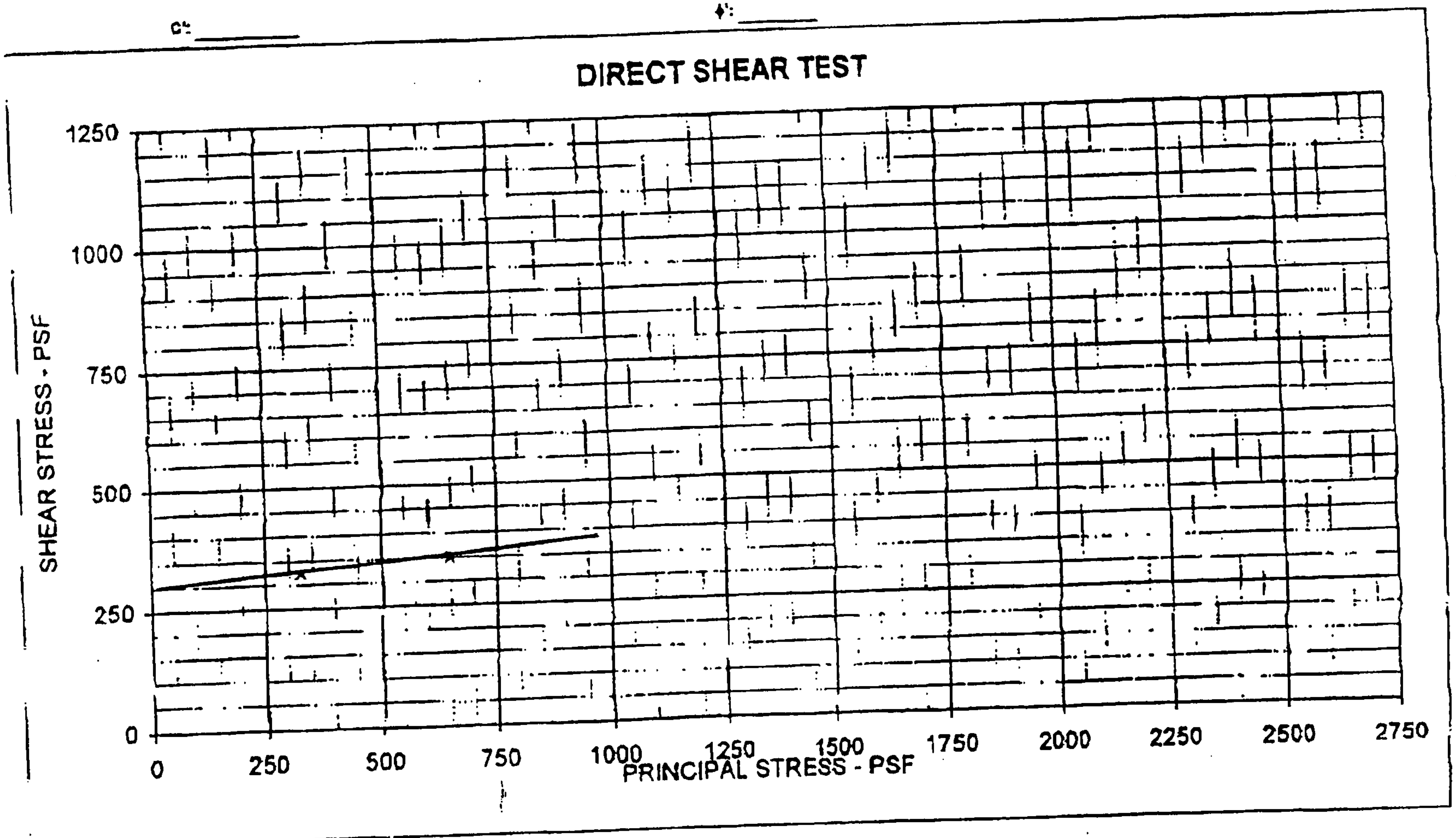
ϕ':

LAB SAMPLE ID:

DEPTH, (FT): 18-20

SATURATION:

σ_3 (PSF)	DRY DENSITY (PCF)	MOISTURE %
323	48.1	81.7
646	43.4	83.2



E2Si

TRIAXIAL TEST (UU)

CLIENT: MICHAEL BAKER JR., INC.

DATE: MAR 23, 1998

PROJECT: HART MILLER ISLAND

PROJECT NO.: 98-035

BORING: B-6

SAMPLE DEPTH: 28'-30'

SAMPLE DESCRIPTION: GRAY SILTY CLAY, TRACE FINE SAND

SAMPLE HEIGHT

BEFORE CONSOLIDATION: 4.25 Inch

AFTER CONSOLIDATION: 4.25 Inch

SAMPLE DIAMETER: 2.8 Inch

WET UNIT WT. OF SAMPLE: 89.6 pcf

RATE OF LOADING= 1.25 mm/min.

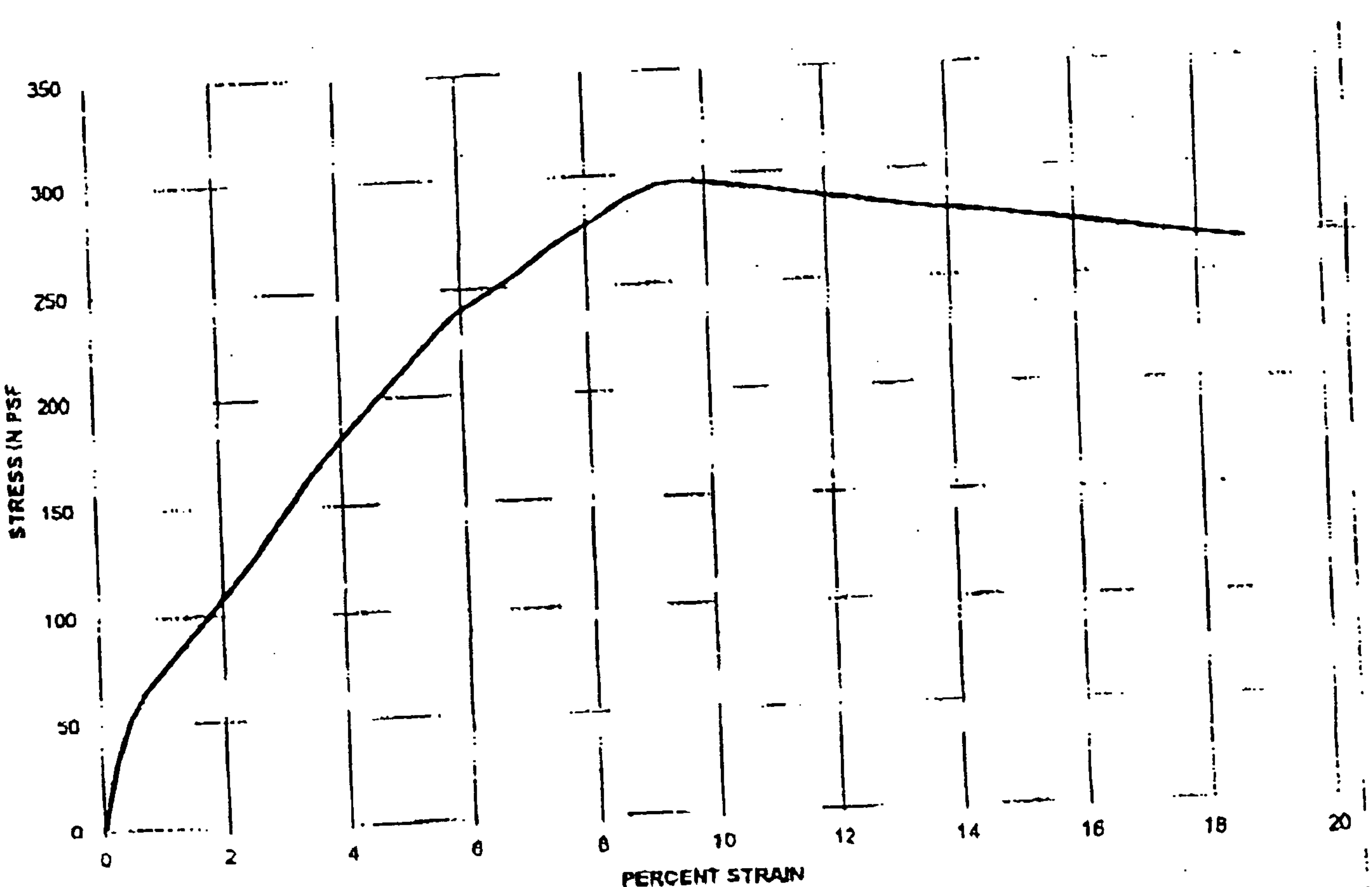
DRY UNIT WEIGHT OF SAMPLE: 43.4 pcf

MOISTURE CONTENT = 106.3 %

CONFINING PRESSURE: 3.5 psi

MAXIMUM DEVIATOR STRESS: 290 psf

STRESS vs STRAIN



E2Si

TRIAXIAL TEST (UU)

CLIENT: MICHAEL BAKER JR., INC.

PROJECT: HART MILLER ISLAND

BORING. B-6

DATE: MAR 23,1998

PROJECT NO.: 98-035

SAMPLE DEPTH: 28'-30'

SAMPLE DESCRIPTION: GRAY SILTY CLAY, TRACE FINE SAND

SAMPLE HEIGHT

BEFORE CONSOLIDATION: 4 Inch

AFTER CONSOLIDATION: 4 Inch

SAMPLE DIAMETER: 2.8 Inch

WET UNIT WT. OF SAMPLE: 88.2 pcf

RATE OF LOADING= 1.25 mm/min

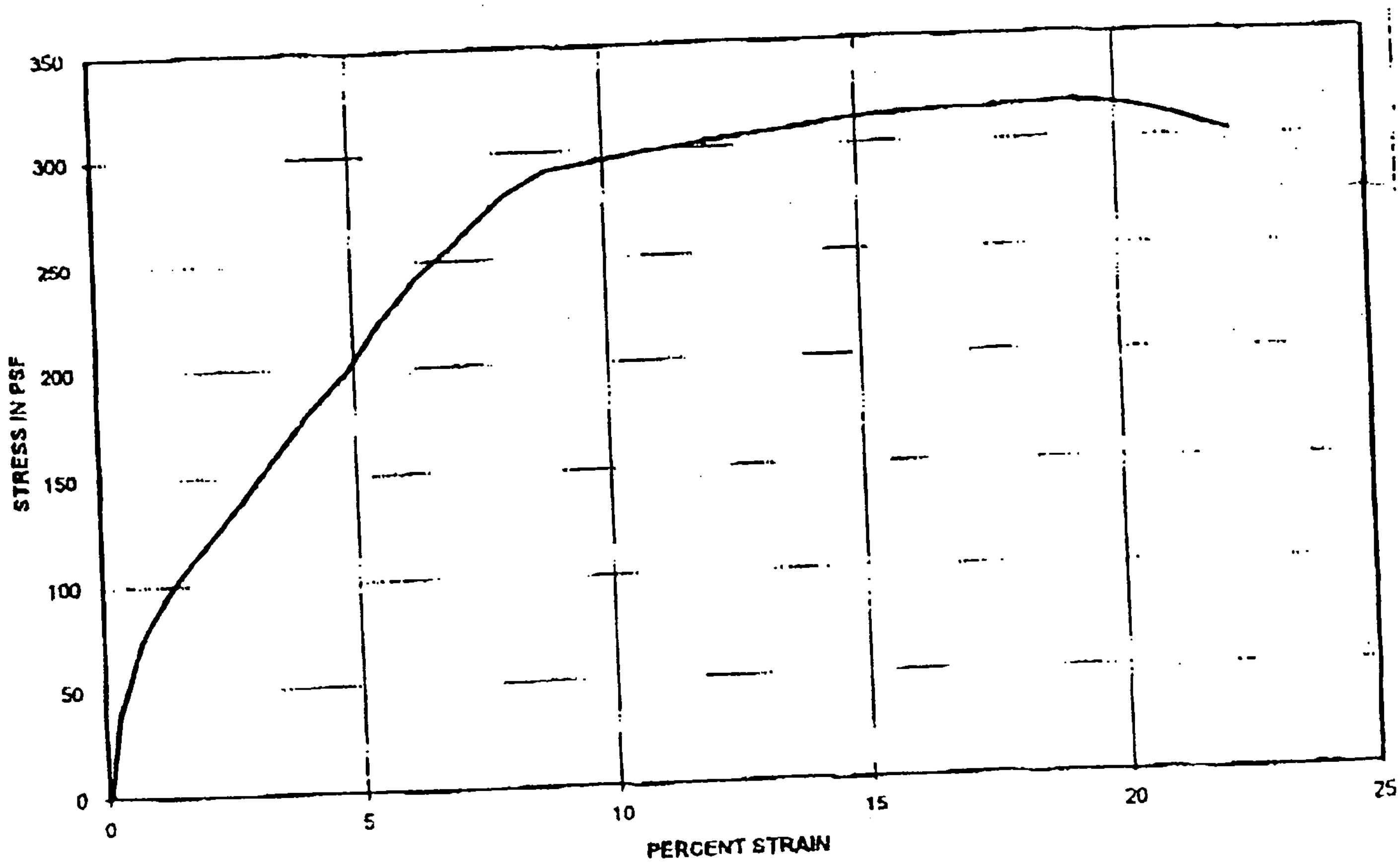
DRY UNIT WEIGHT OF SAMPLE: 42.8 pcf

MOISTURE CONTENT = 106.3 %

CONFINING PRESSURE: 7 psi

MAXIMUM DEVIATOR STRESS 315 psf

STRESS vs STRAIN



E2Si

TRIAXIAL TEST (UU)

LIENT: MICHAEL BAKER JR., INC.

DATE: MAR 23,1998

PROJECT: HART MILLER ISLAND

PROJECT NO.: 98-035

BORING: B-8

SAMPLE DEPTH: 18'-20'

AMPLE DESCRIPTION: GRAY SILTY CLAY, TRACE FINE SAND

AMPLE HEIGHT

EFORE CONSOLIDATION: 5.6 Inch

AFTER CONSOLIDATION: 5.6 Inch

SAMPLE DIAMETER: 2.8 Inch

VET UNIT WT OF SAMPLE: 91.2 pcf

RATE OF LOADING= 1.25 mm/min.

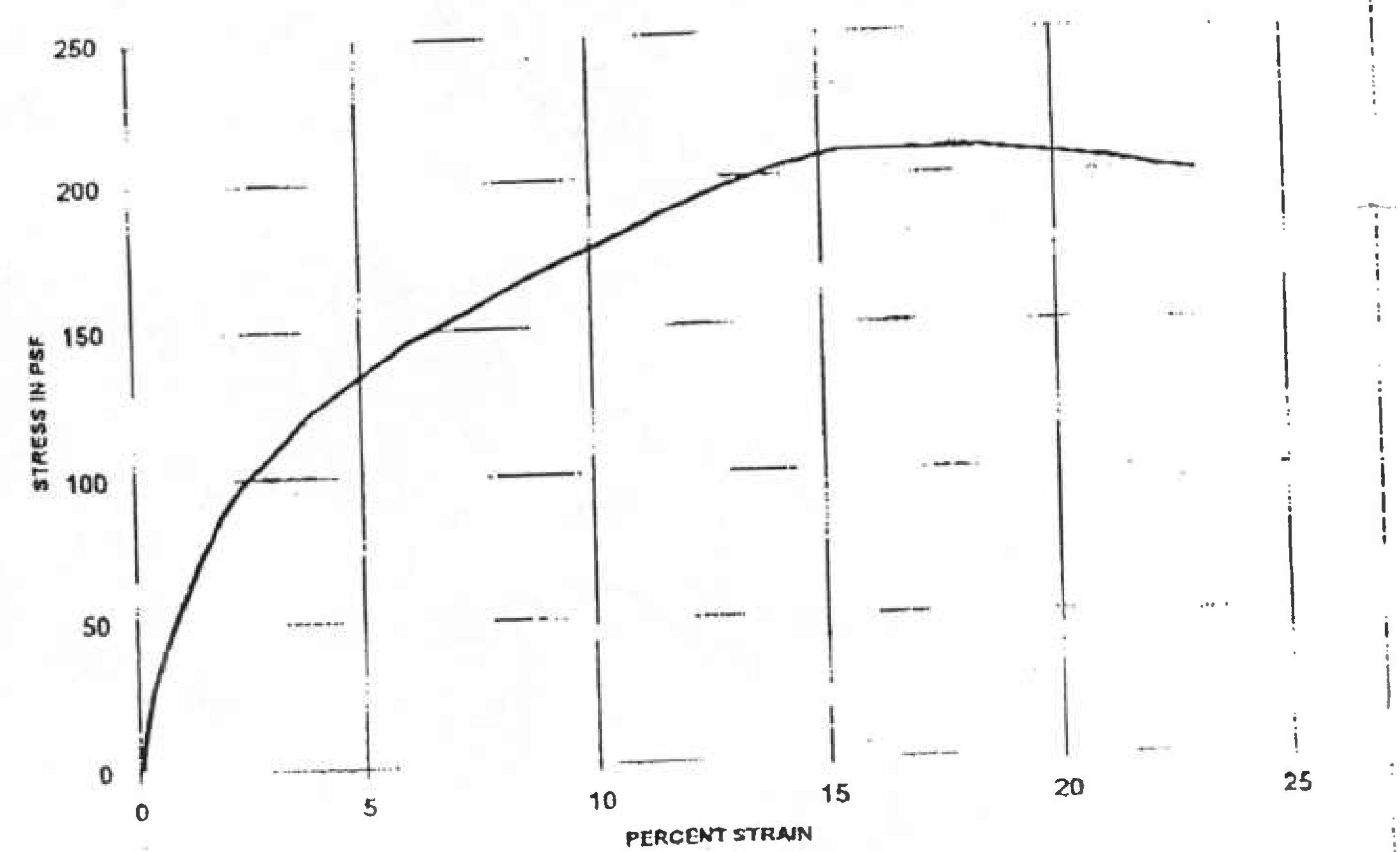
DRY UNIT WEIGHT OF SAMPLE: 48.7 pcf

MOISTURE CONTENT = 87.3 %

CONFINING PRESSURE: 3.5 psi × 144 = 504

MAXIMUM DEVIATOR STRESS: 205 psf ft²

STRESS vs STRAIN



E2Si

TRIAXIAL TEST (UU)

CLIENT: MICHAEL BAKER JR., INC.

PROJECT: HART MILLER ISLAND

BORING: B-8

DATE: MAR 23,1998

PROJECT NO.: 98-035

SAMPLE DEPTH: 18'-20'

SAMPLE DESCRIPTION: GRAY SILTY CLAY, TRACE FINE SAND

SAMPLE HEIGHT
BEFORE CONSOLIDATION: 5.6 Inch
AFTER CONSOLIDATION: 5.6 Inch

SAMPLE DIAMETER: 2.8 Inch

WET UNIT WT. OF SAMPLE: 93.4 pcf

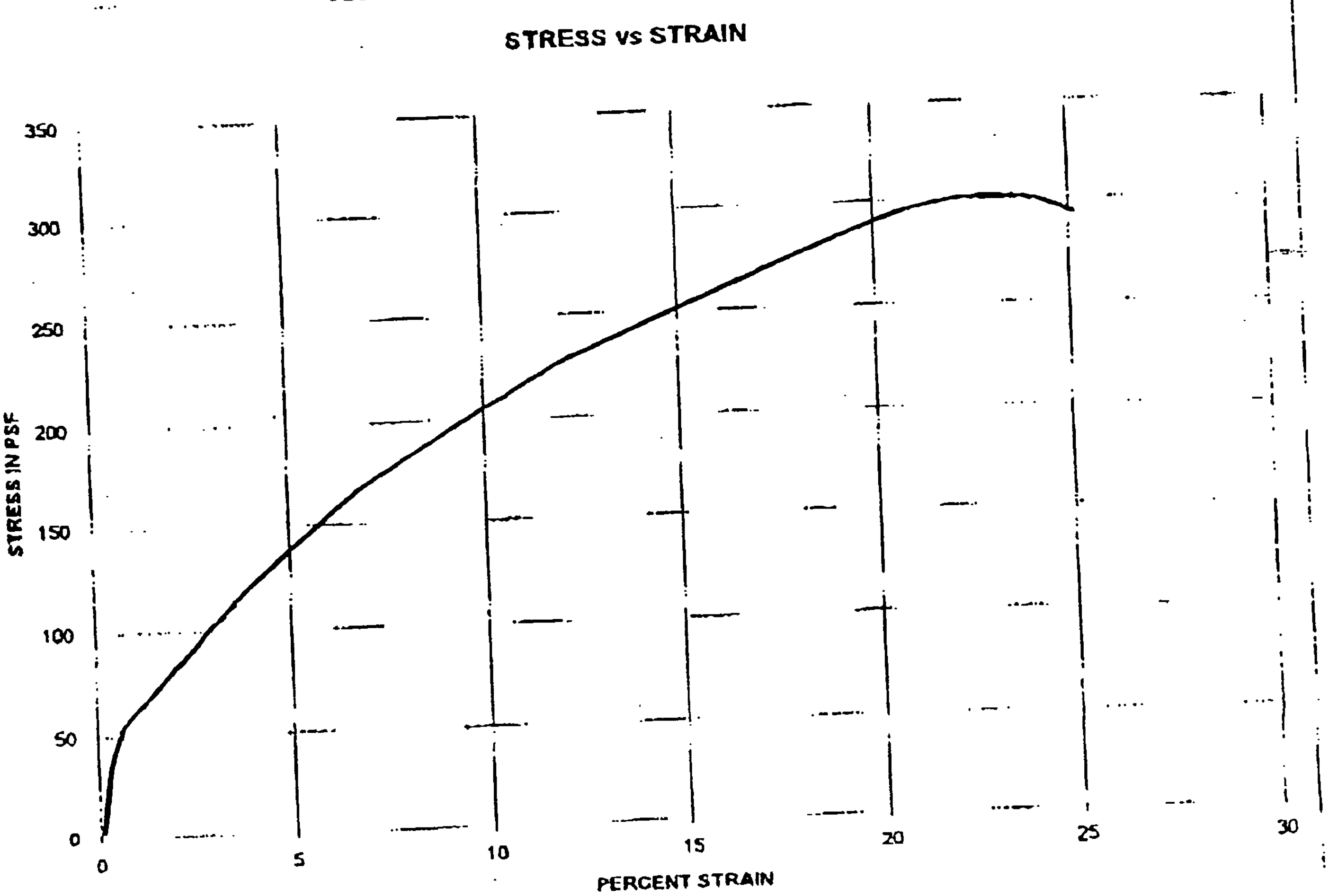
RATE OF LOADING= 1.25 mm/min

DRY UNIT WEIGHT OF SAMPLE: 49.7 pcf

MOISTURE CONTENT = 87.9 %

CONFINING PRESSURE: 7 psi ×144 =100 8

MAXIMUM DEVIATOR STRESS: 300 psf



Appendix V

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

As the client of a consulting geotechnical engineer, you should know that site subsurface conditions cause more construction problems than any other factor. ASFE/The Association of Engineering Firms Practicing in the Geosciences offers the following suggestions and observations to help you manage your risks.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

Your geotechnical engineering report is based on a subsurface exploration plan designed to consider a unique set of project specific factors. These factors typically include: the general nature of the structure involved, its size, and configuration; the location of the structure on the site; other improvements, such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask your geotechnical engineer to evaluate how factors that change subsequent to the date of the report may affect the report's recommendations.

Unless your geotechnical engineer indicates otherwise, do not use your geotechnical engineering report:

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or a refrigerated warehouse will be built instead of an unrefrigerated one;
- When the size, elevation, or configuration of the proposed structure is altered;
- When the location or orientation of the proposed structure is modified;
- When there is a change of ownership; or
- For application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems that may occur if they are not consulted after factors considered in their report's development have changed.

SUBSURFACE CONDITIONS CAN CHANGE

A geotechnical engineering report is based on conditions that existed at the time of subsurface exploration. Do not base construction decisions on a geotechnical engineering report whose adequacy may have been affected by time. Speak with your geotechnical consultant to learn if additional tests are advisable before construction starts. Note, too, that additional tests may be required when subsurface conditions are affected by construction operations at or adjacent to the site, or by natural events such as floods, earthquakes, or ground water fluctuations. Keep your geotechnical consultant apprised of any such events.

MOST GEOTECHNICAL FINDINGS ARE PROFESSIONAL JUDGMENTS

Site exploration identifies actual subsurface conditions only at those points where samples are taken. The data were extrapolated by your geotechnical engineer who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your geotechnical engineer can work together to help minimize their impact. Retaining your geotechnical engineer to observe construction can be particularly beneficial in this respect.

A REPORT'S RECOMMENDATIONS CAN ONLY BE PRELIMINARY

The construction recommendations included in your geotechnical engineer's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Because actual subsurface conditions can be discerned only during earthwork, you should retain your geotechnical engineer to observe actual conditions and to finalize recommendations. Only the geotechnical engineer who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations are valid and whether or not the contractor is abiding by applicable recommendations. The geotechnical engineer who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Consulting geotechnical engineers prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your geotechnical engineer prepared your report expressly for you and expressly for purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the geotechnical engineer. No party should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.

GEOENVIRONMENTAL CONCERNS ARE NOT AT ISSUE

Your geotechnical engineer report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site. The equipment, techniques, and personnel used to perform a geoenvironmental exploration differ substantially from those applied in geotechnical engineering. Contamination can create major risks. If you have no information about the potential for your site being contaminated, you are advised to speak with your geotechnical consultant for information relating to geoenvironmental issues.

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid misinterpretations, retain your geotechnical engineer to work with other project design professionals who are affected by the geotechnical report. Have your geotechnical engineer explain report implications to design professionals affected by them, and then review those design professionals' plans and specifications to see how they have incorporated geotechnical factors. Although certain other design professionals may be familiar with geotechnical concerns, non knows as much about them as a competent geotechnical engineer.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE REPORT

Geotechnical engineers develop final boring logs based upon their interpretation of the field logs (assembled by site personnel) and laboratory evaluation of field samples. Geotechnical engineers customarily include only final boring logs in their reports. Final boring logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes, and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, give contractors ready access to the complete geotechnical engineering report prepared or authorized for their use. (If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared and that developing construction cost estimates was not one of the specific purposes for which it was prepared. In other words, while a contractor may gain important knowledge from a report prepared for another party, the contractor would be well-advised to discuss the report with your geotechnical engineer and to perform the additional or alternative work that the contractor believes may be needed to obtain the data specifically appropriated for construction cost estimating purposes.) Some clients believe that it is unwise or unnecessary to give contractors access to their geotechnical engineering reports because they hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps reduce the adversarial attitudes that can aggravate problems to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical engineers. To help prevent this problem, geotechnical engineers have developed a number of clauses for use in their contracts, reports, and other documents. Responsibility clauses are not exculpatory clauses designed to transfer geotechnical engineers' liabilities to other parties. Instead, they are definitive clauses that identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report. Read them closely. Your geotechnical engineer will be pleased to give full and frank answers to any questions.

RELY ON THE GEOTECHNICAL ENGINEER FOR ADDITIONAL ASSISTANCE

Most ASFE-member consulting geotechnical engineering firms are familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a construction project, from design through construction. Speak with your geotechnical engineer not only about geotechnical issues, but others as well, to learn about approaches that may be of genuine benefit. You may also wish to obtain certain ASFE publications. Contact a member of ASFE or ASFE for a complimentary directory of ASFE publications.

8811 COLESVILLE ROAD/SUITE G 106/SILVER SPRING, MD 20910
TEL: 301/565-2733
FAX: 301/5892017

ASFE PROFESSIONAL FIRMS PRACTICING IN THE GEOSCIENCES

IIGP0294

Final Boring Logs

BORING LOG

FROEHLING & ROBERTSON, INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"
SINCE 1881

Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-1 (1 of 1) | Total Depth 31.5' | Elev: 9.0ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/5/01 | Completed: 9/5/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown and light brown, dry, loose to medium dense, fine, **SILTY SAND (SM)** trace to some gravel	5-8-8	0.0	16	
			5-6-6	2.5	12	
			4-3-3	5.0	6	
			2-4-5	7.5	9	
			7-6-6	10.0	12	
-3.5	12.5	Light brown, tan and light gray, dry medium dense to very dense, fine **SILTY SAND (SM)** with layers of fine SAND (SP), trace rock fragments below 17.5 ft.	6-9-13	12.5	22	
			6-8-10	15.0	18	
			10-18-23	17.5	41	
			14-46-35	20.0	81	
			9-11-14	22.5	25	
-16.0	25.0	Light brown to tan slightly moist, dense fine **SAND (SW-SM)**, trace rock fragments	8-16-18	25.0	34	
-18.5	27.5	Brown, tan and gray, wet, dense, medium to coarse **SAND (SP-SM)** with silt and gravel	9-17-18	27.5	35	Water encountered at 27.1 feet during drilling. Water recorded at 27.9 feet 24 hours after completion.
			11-15-16	30.0	31	
-22.5	31.5	Boring terminated at 31.5 feet				Approximate ground surface elevation provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG

FROEHLING & ROBERTSON, INC.
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SINCE 1881

Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-2 (1 of 1) | Total Depth 11.5' | Elev: 21.0ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/6/01 | Completed: 9/6/02 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown to black, dry, medium dense, fine **SILTY SAND (SM)**, trace gravel and grass	3-6-5	0.0	11	
19.5	1.5	Dark gray and green-blue, moist soft to very soft **CLAY (CH)** (layer of reddish brown fine **SAND (SP)** from 7.5 to 7.9 feet)	2-3-2	2.5	5	
			WH-WH-1	5.0		
			WH-WH-3	7.5 8.3		No water encountered during drilling. Dry upon completion and after 24 hours.
11.0	10.0	Tan, dry, medium dense fine **SAND (SP)**	10-12-13	10.0	25	
9.5	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-3 (1 of 1) Total Depth 11.5' Elev: 19.6ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/6/01 Completed: 9/6/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light to dark brown and dark gray, dry to slightly moist, very soft to medium stiff, fine **SANDY CLAY (CL) and CLAY (CL)** layer of **CLAYEY SILTY SAND (SC-SM)** with gravel in upper 1.5 feet	2-2-4	0.0	6	
			1-2-1	2.5	3	
14.6	5.0	Tan, slightly moist, loose to medium dense, fine **SAND (SP)**	5-8-10	5.0	18	
			3-4-4	7.5	8	Water encountered at 9.5 feet during drilling. Water level at 10.4 feet upon completion and 9.9 feet 24 hours after completion.
9.6	10.0	Dark brown and dark gray, wet, very loose, fine **SILTY SAND (SP**	1-1-2	10.0	3	
8.1	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

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*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-4** (1 of 1)	Total Depth **11.5'**	Elev: **20.9ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/6/01**	Completed: **9/6/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown, dry, very loose fine **SAND (SP)** trace gravel, with iron oxide stains	1-1-2	0.0	3	
18.4	2.5	Dark gray and blue, moist, very soft **CLAY (CL)**	1-1-1	2.5	2	
			0-1-1	5.0	2	
			0-1-1	7.5	2	No water encountered during drilling. Dry upon completion and after 24 hours.
12.5	8.4	Light brown and tan, dry, very loose fine **SAND (SP)**	3-2-1	10.0	3	
9.4	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-5 (1 of 1) | Total Depth 11.5' | Elev: 20.1ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/6/01 | Completed: 9/6/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Reddish brown, dry, loose gravelly SAND (SP) trace grass and roots	2-4-2	0.0	6	
17.6	2.5	Dark gray and brown, slightly moist, very soft to soft CLAY (CL) some iron oxide stains	2-2-2	2.5	4	
			0-1-1	5.0	2	
12.6	7.5	Brown and dark gray, slightly moist to dry, medium dense fine SAND (SP) (clay seams below 10 feet)	2-6-10	7.5	16	No water encountered during drilling. Dry upon completion and after 24 hours.
			6-8-11	10.0	19	
8.6	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-6 (1 of 1) Total Depth 11.5' Elev: 24.5ft ± * Location: See Boring Location Plan

Type of Boring: HSA Started: 9/6/01 Completed: 9/6/01 Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Dark brown, dry, very soft fine **SANDY CLAY** (CL) trace grass roots and gravel to 1.5 feet	1-2-1	0.0	3	
			3-2-1	2.5	3	
			1-1-2	5.0	3	
17.0	7.5	Gray, dark gray and brown, very soft to soft **CLAY** (CL) with seams of fine sand	WOR-0-1	7.5	1	No water encountered during drilling. Dry upon completion and after 24 hours.
			WOH-1-3	10.0	4	
13.0	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.			
Project: South Cell Restoration, Hart-Miller Island, Maryland			
Boring No.: B-7 (1 of 1)	Total Depth 11.5'	Elev: 22.7ft ± *	Location: See Boring Location Plan
Type of Boring: HSA	Started: 9/6/01	Completed: 9/6/01	Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown, dry medium dense, fine **SILTY SAND (SM)** trace roots and gravel	3-8-8	0.0	16	
20.2	2.5	Dark brown, slightly moist, loose **SAND (SP)** and shells, trace clay	4-3-4	2.5	7	
17.7	5.0	Dark brown and gray, slightly moist, medium stiff to soft **CLAY (CH)** (lenses of fine to medium sand, trace shells below 7.5 feet)	6-4-5	5.0	9	
			4-2-2	7.5	4	No water encountered during drilling. Dry upon completion and after 24 hours.
12.7	10.0	Light brown, dry, medium dense, fine, **SAND (SP)**	4-6-7	10.0	13	
11.2	11.5	Boring terminated at 11.5				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Date: 1-30-02

Report No.: C68-122G

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-8 (1 of 1) | Total Depth 11.5' | Elev: 22.5ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/7/01 | Completed: 9/7/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown, dry, medium stiff, fine SANDY CLAY (CL), with grass	2-3-3	0.0	6	
20.0	2.5	Dark gray to black moist, very soft CLAY (CL) (layer of dry fine to medium sand from 8.6 to 9.0 feet)	0-1-1	2.5	2	
			WOH/18"	5.0		
			WOH/18"	7.5		No water encountered during drilling. Dry upon completion and after 24 hours.
12.5	10.0	Dark gray to black, dry, medium dense SAND (SP)	4-7-11	10.0	18	
11.0	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

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*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.			
Project: South Cell Restoration, Hart-Miller Island, Maryland			
Boring No.: B-9 (1 of 1)	Total Depth 31.5'	Elev: 18.3ft ± *	Location: See Boring Location Plan
Type of Boring: HSA	Started: 9/7/01	Completed: 9/7/01	Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Tan, dry, loose to medium dense **SILTY SAND (SM)** trace roots and grass to 1.5 feet (layer of dark brown, moist soft clay from 8.7 to 9.0 feet)	5-7-9	0.0	16	
			9-4-4	2.5	8	
			3-4-7	5.0	11	
			7-6-6	7.5	12	
8.3	10.0	Light gray to dark gray, moist to dry (wet at 13 feet and 20 feet), medium dense, fine to medium **SAND (SP)** (silt layer from 17.5 to 17.8 feet)	12-14-14	10.0	28	
			9-12-15	12.5	27	
			8-12-21	15.0	33	Piezometer well, consisting of one (1) inch diameter PVC tubing and 10 foot well screen (10-slot), installed to 28.5 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 5.9 feet, Sure-Plug bentonite backfill in upper 5.9 ft to ground surface. Finished well stick-up of 1.9 ft. Water encountered at 11.5 ft during drilling. Water recorded at 15.1 ft upon completion. Water recorded at 14.4 ft. below top of well 64 hours after installation.
			20-10-9	17.5	19	
			4-7-11	20.0	18	
-4.2	22.5	Dark gray to light gray, slightly moist to very moist, soft to medium stiff, **SILT (ML)** (lenses of clay and decayed wood below 28 feet)	1-1-3	22.5	4	
			2-3-2	25.0	5	
			1-3-3	27.5	6	
			WOR-2-2	30.0	4	
-13.2	31.5	Boring terminated at 31.5				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 4/11/02

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-10 (1 of 1) | Total Depth 31.5' | Elev: 12.7ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/10/01 | Completed: 9/10/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Brown to tan, moist, loose to very loose, fine **SILTY SAND**, some gravel	2-4-3	0.0	7	
			WH-2-1	2.5	3	
			2-3-4	5.0	7	
6.7	6.0	Gray, wet, medium stiff to stiff fine **SANDY SILT (ML)**	4-4-3	7.5	7	
			5-7-7	10.0	14	
0.2	12.5	Gray, wet, very loose to loose fine **SILTY SAND (SM)**	1-2-3	12.5	5	
			2-2-3	15.0	5	Water encountered at 6.0 feet during drilling
			2-3-2	17.5	5	Water recorded at 13.0 feet upon completion.
			1-2-1	20.0	3	Boring backfilled, no 24 hour readings
			4-4-3	22.5	7	
			4-3-2	25.0	5	
-13.3	26.0	Gray, wet, soft, **CLAYEY SILT (ML)**, some fine sand	1-4-9	27.5	13	
-15.3	28.0	Gray, wet, loose to medium dense, fine **SILTY SAND (SM)**	2-3-7	30.0	10	
-18.8	31.5	Boring terminated at 31.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-11** **(1 of 1)** Total Depth **31.5'** Elev: **22.2ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/12/01** Completed: **9/2/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
22.0	0.2	Topsoil and roots Light brown, dry, very loose fine **SILTY SAND (SM)**	1-1-2	0.0	3	
19.7	2.5	Dark brown and dark gray to black, moist, very soft **CLAY (CH)** trace to some fine sand below 7.5 feet	2-1-2	2.5	3	
			WH-1-1	5.0	2	
			WH-WH-1	7.5		
			WH-1-1	10.0	2	
			WH-1-1	12.5	2	
7.0	15.2	Dark gray to black, wet very loose, fine **SILTY SAND (SM)**	1-2-3	15.0	5	Piezometer well, consisting of one (1) inch diameter PVC tubing and 10 feet well screen installed to 31.5 feet upon completion of boring. Annular borehole space backfilled with "0" well sand to 4.8 feet, Sure-plus ben tonite backfill in upper 4.8 feet to ground surface. Finished well stick up of 30-inches. Water encountered at 14.2 feet during drilling.
4.7	17.5	Dark brown and dark gray, wet, very loose, fine **SILTY SAND (SM)** with clay (dark gray to black below 22.5 feet)	1-1-1	17.5	2	
			1-1-1	20.0	2	
			1-1-1	22.5	2	
			1/2"-1	25.0	100+	
			WH/18"	27.5	100+	
			1/12"-1	30.0	100+	
-9.3	31.5	Boring terminated at 31.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**						
Project: **South Cell Restoration, Hart-Miller Island, Maryland**						
Boring No.: **B-12** (1 of 2)	Total Depth **41.5'**	Elev: **11.0ft ± ***		Location: **See Boring Location Plan**		
Type of Boring: **HSA**	Started: **9/11/01**	Completed: **9/11/01**		Driller: **McNamera**		

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown to brown, moist very loose, fine **SILTY SAND (SM)**	1-2-2	0.0	4	
8.5	2.5	Black, moist, very soft **CLAY (CH)** trace fine sand	3-1-1	2.5	2	
			WH-1-1	5.0	2	
			WH-1/12"	7.5	100+	
2.1	8.9	Gray, wet loose to medium dense, fine **SILTY SAND (SM)**	3-4-6	10.0	10	
			4-5-6	12.5	11	
-3.5	14.5	Light brown, moist, very stiff **SILTY CLAY (CL)**	6-9-10	15.0	19	Piezometer well, consisting of one (1) inch diameter PVC tubing and 20 feet well screen, installed to 41feet upon completion of boring. Annular borehole space backfilled with "0" sand to 4.8 feet, Sure-plus Ben Tonite backfill in upper portion to ground surface. Finished well stick up of 30-inches. Water encountered at 8.9 feet during drilling. Water recorded at 7.1 feet upon completion.
-5.0	16.0	Light brown, wet, loose fine **SAND (SP)**	3-4-3	17.5	7	
-8.0	19.0	Gray, moist to wet, very loose fine **CLAYEY SAND (SC)**	1-1-2	20.0	3	
			3-3-6	22.5	9	
-12.0	23.0	Gray, wet, medium stiff **CLAYEY SILT (ML)** with fine sand	1-1-2	25.0	3	
-14.5	25.5	Gray, wet, very loose to medium dense fine **SILTY SAND (SM)**	1-4-5	27.5	9	
			4-10-10	30.0	20	
			4-5-5	32.5	10	
			4-6-5	35.0	11	
			3-4-5	37.5	9	
-28.0	39.0	Gray, moist, soft, fine **SANDY SILT (ML)**, trace				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** | Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-12** (2 of 2)	Total Depth **41.5'**	Elev: **11.0ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/11/01**	Completed: **9/11/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		clay	1-2-2	40.0	4	
-30.5	41.5	Boring terminated at 41.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-13** **(1 of 2)** Total Depth **41.5'** Elev: **11.6ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/11/01** Completed: **9/12/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		Light brown and gray, moist, very loose to medium dense like **SILTY SAND (SM)**, some gravel, layer of very soft lean clay from 1.0 to 1.5 ft	2-1-1	0.0	2	
			6-6-5	2.5	11	
7.1	4.5	Tan, moist, medium dense to dense **SILTY SAND (SM)** with lenses of silt (black and wet below 6.5 ft)	4-10-13	5.0	23	
			9-13-18	7.5	31	Water encountered at 6.5 ft during drilling. Water at 8.4 ft upon completion.
			5-3-9	10.0	12	
			1-2-6	12.5	8	
			4-12-14	15.0	26	
-3.9	15.5	Tan, wet, very loose to medium dense, fine **SAND (SP-SM)** with silt				
			1-2-1	17.5	3	
			3-5-4	20.0	9	
-9.4	21.0	Gray, wet, very loose to medium dense fine **SANDY SILTY CLAY (CL) and SANDY SILT (ML)**				
			8-2-2	22.5	4	
			2-7-8	25.0	15	
			4-9-9	27.5	18	
-16.4	28.0	Gray, wet, medium dense to loose, fine **SILTY SAND (SM)**				
			3-6-14	30.0	20	
			7-9-9	32.5	18	
			3-4-6	35.0	10	
-24.4	36.0	Gray, moist to wet, very loose fine **SANDY SILT (ML)** trace clay				
			2-2-2	37.5	4	

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: **C68-122G** Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**				
Project: **South Cell Restoration, Hart-Miller Island, Maryland**				
Boring No.: **B-13** **(2 of 2)**	Total Depth **41.5'**	Elev: **11.6ft ± ***	Location: **See Boring Location Plan**	
Type of Boring: **HSA**	Started: **9/11/01**	Completed: **9/12/01**	Driller: **McNamera**	

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
			2-2-2	40.0	4	
-29.9	41.5	Boring terminated at 41.5 ft				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 4/15/02

BORING LOG

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Report No.: **C68-122G** | Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-14** (1 of 1)	Total Depth **31.5'**	Elev: **24.9ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/12/01**	Completed: **9/13/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)
24.1	0.8	TOPSOIL
		Dark gray, dry, loose to very loose, fine **SILTY SAND (SM)**
21.4	3.5	Black, moist, very soft **CLAY (CH)** trace fine sand sand
14.9	10.0	Dark gray to black, dry very loose to loose fine **CLAYEY SAND (SC)** and **SILTY SAND (SM)**
9.9	15.0	Dark gray to black, wet very loose, fine to medium **SAND (SP)** trace shell fragments
4.9	20.0	Dark gray to black wet, very soft fine **SANDY CLAY (CL)**
2.4	22.5	Dary gray to black, wet very loose, fine **SILTY SAND (SM)** trace clay and shell fragments
-6.6	31.5	Boring terminated at 31.5 ft

* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)
3-4-4	0.0	8
1-1-1	2.5	2
WH-1-1	5.0	2
WH-1-1	7.5	2
1-1-2	10.0	3
3-3-3	12.5	6
2-2-1	15.0	3
1-1-2	17.5	3
WH/18"	20.0	
WH-1-1	22.5	2
WH/12"-1	25.0	
1-1-1	27.5	2
WH-1-2	30.0	3

REMARKS

Piezometer well, consisting of one (1) inch diameter PVC tubing and 20 foot well screen (10-slot), installed to 29.0 ft upon completion of boring. Annular borehole space backfilled with # well sand to 6.9 ft, Sure-Plug bentonite backfill in upper 6.9 ft to ground surface. Finished well stickup of 2.5 ft.
Water encountered at 14.5 ft during drilling. Water recorded at 17.3 ft below top of stick-up upon completion of well installation. Water recorded at 17.0 ft below top of well 4 days after installation.

*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**			
Project: **South Cell Restoration, Hart-Miller Island, Maryland**			
Boring No.: **B-15** (1 of 1)	Total Depth **11.5'**	Elev: **19.8ft ± ***	Location: **See Boring Location Plan**
Type of Boring: **HSA**	Started: **9/13/01**	Completed: **9/13/01**	Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-2-2	0.0	4	Piezometer well, consisting of one (1) inch diameter PVC tubing and 5 foot well screen (10-slot), installed to 28.5 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 3 feet, Sure-Plug bentonite backfill in upper 3 ft to ground surface. Finished well stick-up of 2.5 ft. No water encountered during drilling or upon completion
18.9	0.9	Light brown, moist, very loose, fine **CLAYEY SAND (SC)** trace silt	1/12"-1	2.5	100+	
16.3	3.5	Dark brown, moist, very loose **SILT (ML)** trace fine sand with layers of fat clay (CH)	1/18"	5.0	100+	
			WOH/18"	7.5	100+	
			WOH/18"	10.0	100+	
8.3	11.5	Boring terminated at 11.5 feet				

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.			
Project: South Cell Restoration, Hart-Miller Island, Maryland			
Boring No.: B-16 (1 of 1)	Total Depth 11.5'	Elev: 19.0ft ± *	Location: See Boring Location Plan
Type of Boring: HSA	Started: 9/13/01	Completed: 9/13/01	Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	WH-1-1	0.0	2	Piezometer well, consisting of one (1) inch diameter PVC tubing and 5 foot well screen (10-slot), installed to 10 feet upon completion of boring. Annular borehole space backfilled with #1 well sand to 3.1 feet, Sure-Plug bentonite backfill in upper 3.1 ft to ground surface. Finished well stick-up of 3.0 ft. No water encountered during drilling or upon completion.
18.1	0.9	Brown, moist, very loose fine **SILTY SAND (SM)** trace roots	WH-1-1	2.5	2	
16.0	3.0	Dark brown and dark gray moist, very soft **CLAYEY SILT (ML)** trace fine sand	WH/12"-1	5.0		
			WH/18"	7.5		
			WH/18"	10.0		
7.5	11.5	Boring terminated at 11.5 ft				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-17** **(1 of 1)** Total Depth **11.5'** Elev: **19.1ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/13/01** Completed: **9/13/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-1/2"	0.0	100+	
17.6	1.5	Dark gray to black, moist, very loose **SILT (ML)** trace fine sand with layers of lean clay (CL) and fat clay (CH)	1/12"-1	2.5	100+	No water encountered during drilling or upon completion above the cave-in at 3.8 feet
			1/18"	5.0	100+	
			WH/18"	7.5	100+	
			WH/18"	10.0	100+	
7.6	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

BORING LOG C68-122.GPJ F&R.GDT 4/15/02

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

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Report No.: C68-122G

Date: 1-30-02

Client: Michael Baker Jr., Inc.

Project: South Cell Restoration, Hart-Miller Island, Maryland

Boring No.: B-18 (1 of 1) | Total Depth 11.5' | Elev: 18.5ft ± * | Location: See Boring Location Plan

Type of Boring: HSA | Started: 9/13/01 | Completed: 9/13/01 | Driller: McNamera

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1-1-1	0.0	2	
17.6	0.9	Dark gray, moist, very loose, fine SANDY SILT (ML)				
			WH/12"-1	2.5		
			WH/12"-1	5.0		
			WH/18"	7.5		
			WH/18"	10.0		No water encountered during drilling or upon completion
7.0	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

BORING LOG

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Report No.: **C68-122G**

Date: **1-30-02**

Client: **Michael Baker Jr., Inc.**

Project: **South Cell Restoration, Hart-Miller Island, Maryland**

Boring No.: **B-19** **(1 of 1)** Total Depth **11.5'** Elev: **19.1ft ± *** Location: **See Boring Location Plan**

Type of Boring: **HSA** Started: **9/13/01** Completed: **9/13/01** Driller: **McNamera**

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows	Sample Depth (feet)	N Value (blows/ ft)	REMARKS
		TOPSOIL	1/12"-1	0.0		
17.9	1.2	Black, moist to wet, very loose, fine **SANDY SILT (ML)**	4-1/18"	2.5		
			WH/18"	5.0		
			9-WH/18"	7.5		No water encountered during drilling or upon completion about the cave-in at 3.8 feet
			WH/18"	10.0		
7.6	11.5	Boring terminated at 11.5 feet				*Ground surface elevation based on listing provided by Michael Baker Jr. Inc.

BORING LOG C68-122.GPJ F&R.GDT 2/21/02

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N.

Responses to US Army Corps of Engineers Comments
35% Design Review

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Web Site: www.FandR.com

April 10, 2002

Michael Baker, Inc.
801 Cromwell Park Drive, Suite 110
Glen Burnie, Maryland 21061

Attn: Ms. Michele Monde

Re: **Report of Geotechnical Engineering Analysis and Recommendations**
Proposed South Cell Restoration
Hart-Miller Island
Chesapeake Bay - Baltimore County, Maryland
F&R Project No. C68-122G

Dear Ms. Monde:

Response is given herein to Comments 33919 thru 33922 submitted by the US Army Corps of Engineers (USACE) regarding our Geotechnical Report dated February 21, 2002. This additional submittal is provided as requested and in accordance with our Subconsultant Agreement for Professional Services dated 17th day of July, 2001, and our related proposal letter dated May 10, 2001.

Complete text of the comments is given by the enclosed Partial Listing of Review Comments. Our response is as follows for each Comment No. listed:

Additional test borings, sampling, and drained shear strength tests would be necessary to provide sufficient data to satisfy requirements indicated by comment No. 33920. As we have noted in Section 5.3.1 of the Geotechnical Report, this additional study may be necessary and appropriate for preparation of the final plans for this project.

No. 33921 - Calculations

Calculations are enclosed as requested for the Nesting Island settlement, and design recommendations for the Pump Station.

No. 33922 - Field Survey Differences - 2001 and 1997 data

Considering the apparent earth moving activity on the island during the period of our site investigation, we believe mechanical excavation is a likely cause for the lower elevation indicated by the 2001 survey at Cross Section 4. It should be noted that slope stability calculations given by the Geotechnical Report for this location are based on the more critical condition indicated by the 2001 field survey.

We trust the additional comments and enclosed calculations satisfactorily answer concerns indicated by the enclosed Partial Listing of Review Comments. We appreciate the opportunity to be of continued service to you on this project. If you have any questions concerning this submittal, please contact the undersigned.

Respectfully,

Froehling & Robertson, Inc.

Raymond Hansen

Raymond Hansen, P.E.
Senior Geotechnical Engineer

STATE OF MARYLAND
FRANKLIN D. GREFSHEIM
No. 8597
REGISTERED
PROFESSIONAL ENGINEER

Franklin D. Grefsheim, P.E.
State of Maryland

Enclosures: Partial Listing of Review Comments (One Sheet)
Calculations - Settlement and Pump Station (Two Sheets)
Additional Slope Stability Summary Plots, Section 4 (Two Sheets)

FAX Copy: One - Transmitted on April 10, 2002
2 Copies: Enclosed

PARTIAL LISTING OF REVIEW COMMENTS

Consider draining valve pit to wet well via flap check valve, sump or other suitable arrangement.
Submitted by Mr Joseph Miklusak (voice: 410-962-6705 email: Joseph.J.Miklusak@nab02.usace.army.mil) on 21-Dec-01.
Designer non-concurred on 13-Feb-02:
This comment is not applicable any more because the valve pit has been removed from the design.

29434	n/a	PS-09	(not identified)	Civil

What type of piping materials are being considered for intake, force main and distribution lines? Will the piping system require any special protection?
Submitted by Mr Joseph Miklusak (voice: 410-962-6705 email: Joseph.J.Miklusak@nab02.usace.army.mil) on 21-Dec-01.
Designated as information only on 13-Feb-02:
Plastic piping (HDPE)will be used for the lines. No special protection will be required.

* 33919	Geotech Report	(not identified)	(not identified)	Geotechnical

Further explanation of the material properties used in the slope stability analysis is required. If direct shear or triaxial test results were used, the appropriate samples and results need to be identified. If SPT correlations were used, then specify which borings, and which depths were used. State any other methods which were used to obtain the strength properties.
Submitted by Mr David Capka (voice: 410-962-6811 email: david.e.capka@usace.army.mil) on 01-Apr-02.

* 33920	Geotech Report	(not identified)	(not identified)	Geotechnical

Specify what stress condition(s) was used in the slope stability analysis. It appears that the steady-seepage (long-term) condition was analyzed in the cases shown. If that is the case, no cohesion should be used for the material strengths. If the end-of-construction (short-term) condition is being analyzed, phi should be zero for low permeability soils.
Submitted by Mr David Capka (voice: 410-962-6811 email: david.e.capka@usace.army.mil) on 01-Apr-02.

* 33921	Geotech Report	(not identified)	(not identified)	Geotechnical

Need to provide calculations for settlement (Nesting Island) and the pump station bearing capacity, settlement and uplift resistance.

Submitted by Mr David Capka (voice: 410-962-6811 email: david.e.capka@usace.army.mil) on 01-Apr-02.

* 33922	Geotech Report	(not identified)	(not identified)	Geotechnical

Why is the field survey from 2001 for x-section 4 (and other sections not used in the stability analysis) much lower in elevation than the 1997 aerial survey? If this is due to something other than aerial survey error, slope stability may be compromised by continual lowering of the swale. Potential causes could be erosion due to water velocities or mechanical excavation of the material for use on-site. In either case, the stability analysis needs to take into account the worst potential case.
Submitted by Mr David Capka (voice: 410-962-6811 email: david.e.capka@usace.army.mil) on 01-Apr-02.

33923	Geotech Report	(not identified)	(not identified)	Geotechnical

Backfill under and around the Bay Connector Culvert and Force Main needs to be addressed. Will imported fill need to be used, or can on-site soils be used?
Submitted by Mr David Capka (voice: 410-962-6811 email: david.e.capka@usace.army.mil) on 01-Apr-02.

33924	Geotech Report	(not identified)	(not identified)	Geotechnical

CLR-122G Settlement 2/20/02

NESTING ISLAND use 3 ft fill, 300' x 300' area

Soil properties and profile per E2SI B-7
for SILTY CLAY consider a lean clay soil
with LL = 50, assume $e_0 = 1.0$

$C_c = 0.009(LL-10) = 0.009(50-10) = 0.36$

PROFILE EL.

— 20

consider 30 ft of normally
consolidated inorganic soil
water at ground surface

— 10

at $Z = 15$ (layer center)

N = WOH
to 2 bpf

$p_0 = 15\,\gamma_s$ $\quad \gamma_s \sim 60\,pcf$

— 0

$= 15(60) = 900$

Δp for 3 ft of proposed fill

$\Delta p = 3(125) = \underline{375}$

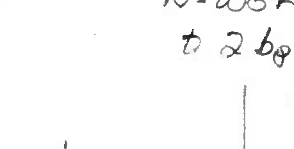
— -10

$p_f = 1275\ psf$

$$S = \frac{C_c H}{1+e_0}\log\left(\frac{p_f}{p_0}\right) = \frac{0.36(30)(12)}{2}\log\left(\frac{1275}{900}\right) = 9.8''$$

$\boxed{\text{say } S = 10 \text{ inches at center}}$

Δp at center of edge



$Z = 15'$

$mZ = 100,\ m = 6.7$

$nZ = 300,\ n = 20$

$I = 2(0.25) = 0.5 \qquad \Delta P = 0.5(3)(125) = 187.5$

$$S = \frac{0.36(30)(12)}{2}\log\left(\frac{900+187.5}{900}\right) = 5.3''$$

$\boxed{\text{say } S = 5 \text{ inches at edges}}$

C68-1229 Pump Station 2/19/02

use 100,000# total load on min 17x24.5, 2' base

base slab subgrade, min dep th EL -19

per B-12 expect suitable bearing

SILTY SAND, N=10 to 20 bpf

Bearing Capacity Consideration

$100^k / 17 \times 24.5 = 240$ psf << 500 psf O.K.

Uplift Resistance

use pond elevation 0.0

uplift = $19 \times 62.4 \times (24.5 \times 17) = 494$ kips

download:

A. 100 kip structure dead load

B. 30° annular wedge

$$A_{ave} = \frac{A_1 + A_2}{2} = \frac{(24.5 \times 17) + (46 \times 38)}{2} = 1082 \, \square'$$

$h = 19'$, $V_{TOTAL} = 1082 \times 19 = 20558$

$V_{PUMP} = 24.5 \times 17 \times 19 = 7913$

$V_{ANNULAR\ SPACE} = 12645 \, ft^3$

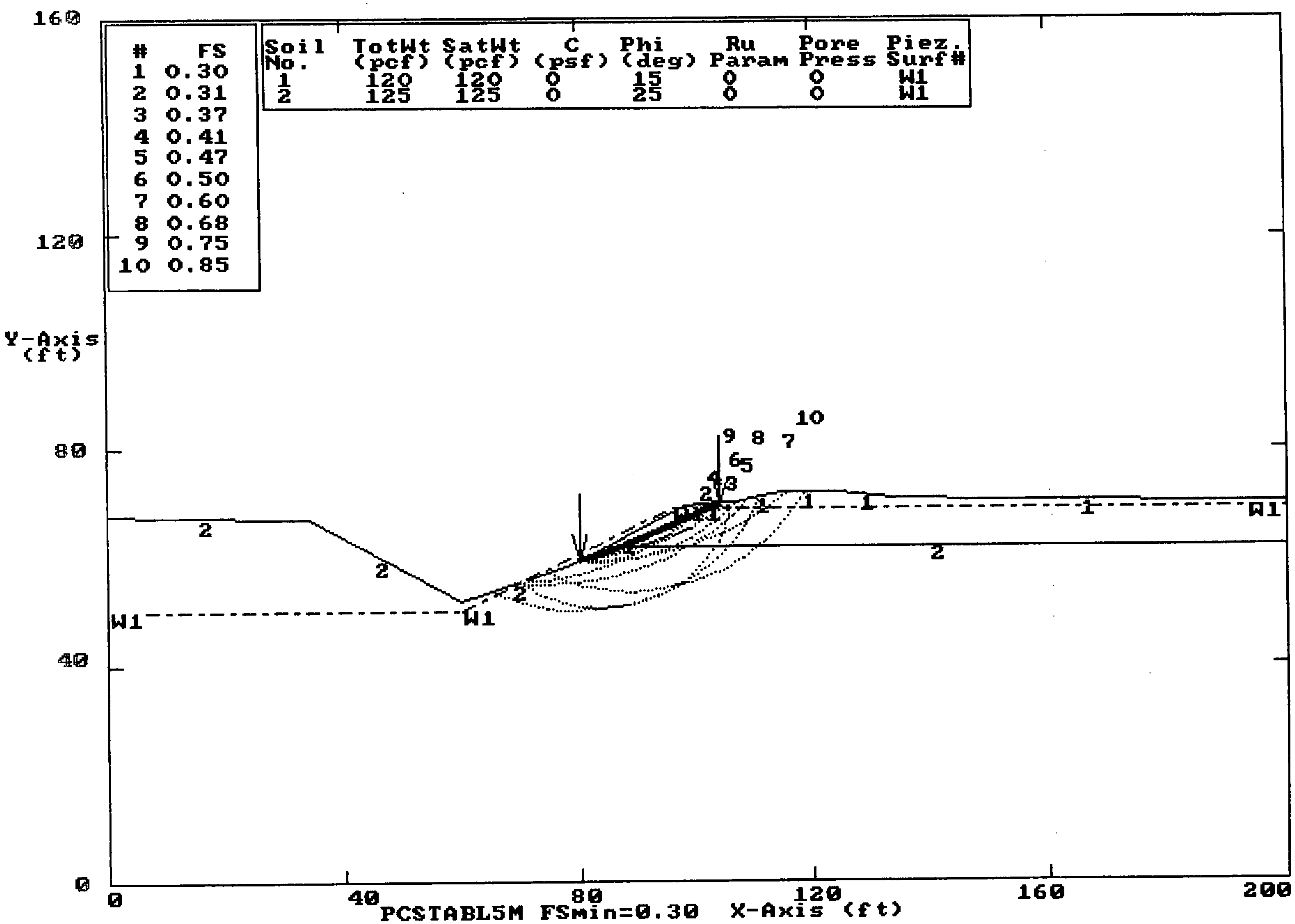
addl. download $= 12645 (0.062) = 784$

$$FS = \frac{W_T}{P} = \frac{100 + 784}{494} = \boxed{1.8}$$

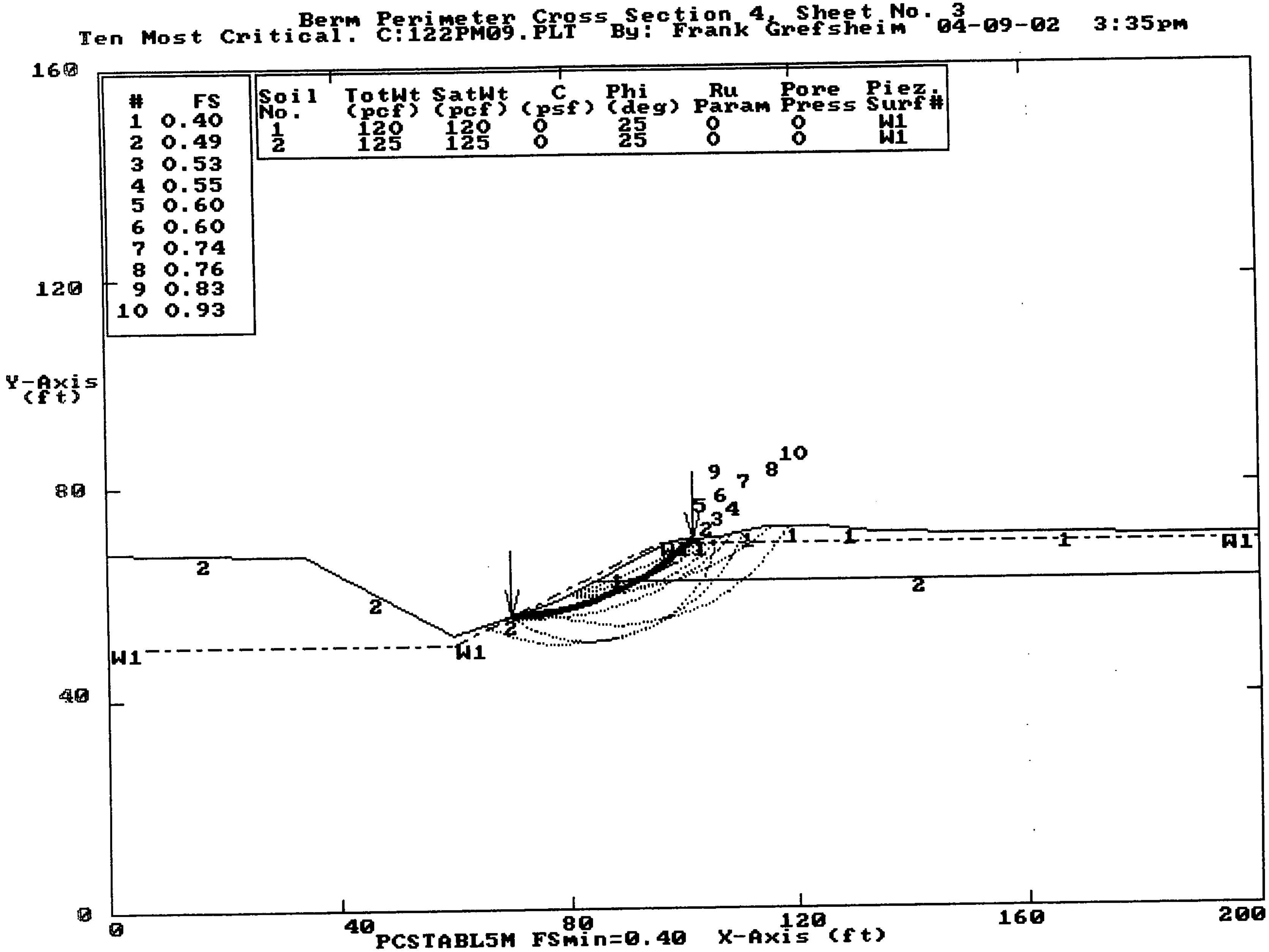
recommend minimum 1.0 ft slab oversize for full development of soil overburden

ignore increase of uplift factor from oversizing

Berm Perimeter Cross Section 4, Sheet No. 3
Ten Most Critical. C:122PM08.PLT By: Frank Grefsheim 04-09-02 1:37pm



ADDITIONAL SLOPE STABILITY SUMMARY PLOTS
SHEET 1 OF 2



ADDITIONAL SLOPE STABILITY SUMMARY PLOTS
SHEET 2 OF 2

Responses to US Army Corps of Engineers Comments
95% Design Review

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June 10, 2002

Michael Baker, Inc.
801 Cromwell Park Drive, Suite 110
Glen Burnie, Maryland 21061

Attn: Ms. Michele Monde

Re: **Report of Geotechnical Engineering Analysis and Recommendations**
Proposed South Cell Restoration
Hart-Miller Island
Chesapeake Bay - Baltimore County, Maryland
F&R Project No. C68-122G

Dear Ms. Monde:

Response is given herein to Comments 51237, 51238 and 51241 received from the US Army Corps of Engineers (USACE) regarding our Geotechnical Report dated February 21, 2002, and your related plan submittals. Our response herein is provided as requested and in accordance with our Subconsultant Agreement for Professional Services dated 17th day of July 2001, and our related proposal letter dated May 10, 2001.

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA 23261-7524
TELEPHONE (804) 264-2701 • FAX (804) 264-1202

BRANCHES: ASHEVILLE, NC • ATLANTA, GA • BALTIMORE, MD • CHARLOTTE, NC
CHESAPEAKE, VA • CROZET, VA • FAYETTEVILLE, NC • FREDERICKSBURG, VA
GREENVILLE, SC • RALEIGH, NC • ROANOKE, VA • STERLING, VA • WINSTON-SALEM, NC

Complete text of the comments is given by the enclosed Partial Listing of Review Comments. Our response is as follows for each Comment No. listed:

No. 51238 - Base of Pump Station Correction to El -10

At the corrected proposed base slab level of El -10 for the pump station, we anticipate generally looser subsoils. However, the subsoils at a minimum depth subgrade of El -10 should be suitable for support of the slab based on the estimated very low unit loading of less than 500 psf.

Recommendations, given by Section 5.7 Earthwork of our Geotechnical Report, will apply regarding earthwork in areas of soft subgrades. Use of a crushed stone base may be necessary to provide a working surface for placement of the slab concrete. For the plans, we recommend indicating a minimum 6-inch thick layer of crushed stone satisfying MDOT Coarse Aggregate Size No. 57 or approved equivalent.

Our revised analysis still indicates a net uplift. Accordingly, we still recommend oversizing the slab as described in Section 5.4 Pump Station of our Geotechnical Report. A revised increased factor of safety, FS = 3.4, will apply for a based slab raised from El -19 to the corrected level of El -10.

As noted above, our calculations indicate a net uplift related to construction for the proposed pump station. Settlement would consist of recompression after rebound of the underlying subsoils, which are primarily silty sand. There may also be some minor settlement movement resulting from disturbance caused by the excavation construction. These settlements should be minor, less than 1.0 inch.

No. 51241 - Geotechnical Report Paragraph 5.3.1, Marginal Factor of Safety

In the slope stability analysis for the proposed perimeter berm, we have indicated the possible need to fill across the ravine at Cross Section 4 (Station 13+72.4) because of the marginal factor of safety value, FS = 1.27. In addition to filling for the slope stabilization, we have indicated that further evaluations of soil shear strength parameters and subsoil profile may be necessary or advisable. However, we understand it is desired to provide stabilization by filling across the ravine. Details for this option, as given below, are based on existing shear strength parameters and soil profile data.

Results of additional calculations are given by the enclosed Berm Perimeter Section 4R. As indicated thereon, the revised cross section shown includes filling the adjacent ravine, which is located just south of the proposed berm. Filling is indicated from the existing grade of El +1.5 to a proposed finished grade of El +10.5. For this revised proposed cross section, our calculations indicated an increased factor of safety, FS = 1.49, which should be adequate.

Similar marginally safe slope conditions apply at Cross Sections 2 thru 6. For the final plans, we recommend indicating filling of the ravine to El +10.5 from Station 0+00 to Station 24+90.

For practical earthwork construction, we recommend using on-site sandy soils for filling this ravine. Other recommendations regarding the earthwork will apply as given in Section 5.7 Earthwork of our Geotechnical Report for this project.

No. 51237 - Backup Calculations

Calculations are enclosed as requested regarding estimated settlement for the proposed berm fill.

We trust the additional comments and enclosed calculations satisfactorily answer concerns indicated by the enclosed Partial Listing of Review Comments. We appreciate the opportunity to be of continued service to you on this project. If you have any questions concerning this submittal, please contact the undersigned.

Respectfully,

Froehling & Robertson, Inc.

Ray Hansen / FG

Raymond Hansen, P.E.
Senior Geotechnical Engineer

STATE OF MARYLAND
FRANKLIN D. GREFSHEIM
PROFESSIONAL ENGINEER

Franklin [illegible]
[illegible]land

Enclosures: Partial Listing of Review Comments (Three Sheets)
Berm Perimeter Cross Section 4R (One Sheet)
Settlement Calculations

FAX Copy: One - Transmitted on June 10, 2002
2 Copies: Enclosed

Submitted by Michael Stello (410-962-4314) on 13-May-02. Revised on 14-May-02.

New Evaluation: ○ Concur ○ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

– [illegible] borings will be available.
– [illegible] type boring#

Attachment: instructions [ ] Browse... | Add

51222	Discipline: Civil DocType: Plans	n/a	C-15

Walkway Detail. Show a prime coat and the designation of the base course material. Revise the specs to agree with the designations for asphalt course and base course as necessary. In the last note, change "Director" to "Contracting Officer". If the bituminous course is increased to 3.5 inches, require a tack coat between 2 layers of bituminous.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Clarify detail / Prime coat / designation
Δ Cont officer. – eliminate option
Tack coat – not applicable

Attachment: instructions [ ] Browse... | Add

51228	Discipline: Structural DocType: Plans	n/a	PS-03

The base of the pump station is at elevation -10, which does not agree with the geotechnical report. Coordinate and revise the design analysis.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

pump -10'

Attachment: instructions [ ] Browse... | Add

51231	Discipline: Civil DocType: Plans	n/a	PS-13

Access Road Section Note. This note references a blank spec section. Revise.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Attachment: instructions [ ] Browse... | Add

51234	Discipline: Civil DocType: Plans	n/a	PS-16

Section 2:PS-16. Select Fill Note. Why is VDOT referenced?
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Add

Attachment: instructions Browse...

51237	Discipline: Geotechnical DocType: Design Analysis	n/a

Page 8, para. 5.3.2. Provide backup calculations for settlement of the proposed berm.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve

☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Add

Attachment: instructions Browse...

SBU

Project: Hart-Miller Island Restoration. Contact a manager if needed.
Review: Final Design *(control number DRC2132)*

Review schedule from 08-May-02 to 08-May-02.

ID/Keyword: Discipline: Pick to search list. DocType: Pick to search list. Search Reset

ID	Index Categories: Values	Spec	Sheet	Detail	Action
51238	Discipline: Geotechnical DocType: Design Analysis	n/a			

Page 9, para.5.4, Pump Station. The design for the pump station was based on elevation -19. The drawings indicate that the base is at elevation -10. Revise the analysis and include settlement calculations.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve
☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Attachment: instructions Browse... Add

ID	Index Categories: Values	Spec
51241	Discipline: Geotechnical DocType: Design Analysis	n/a

Page 8, para.5.3.1, Slope Stability, last subparagraph. The proposed contingency plan due to the lower FS for stability has not been incorporated into the contract documents. Revise.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve
☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Attachment: instructions Browse... Add

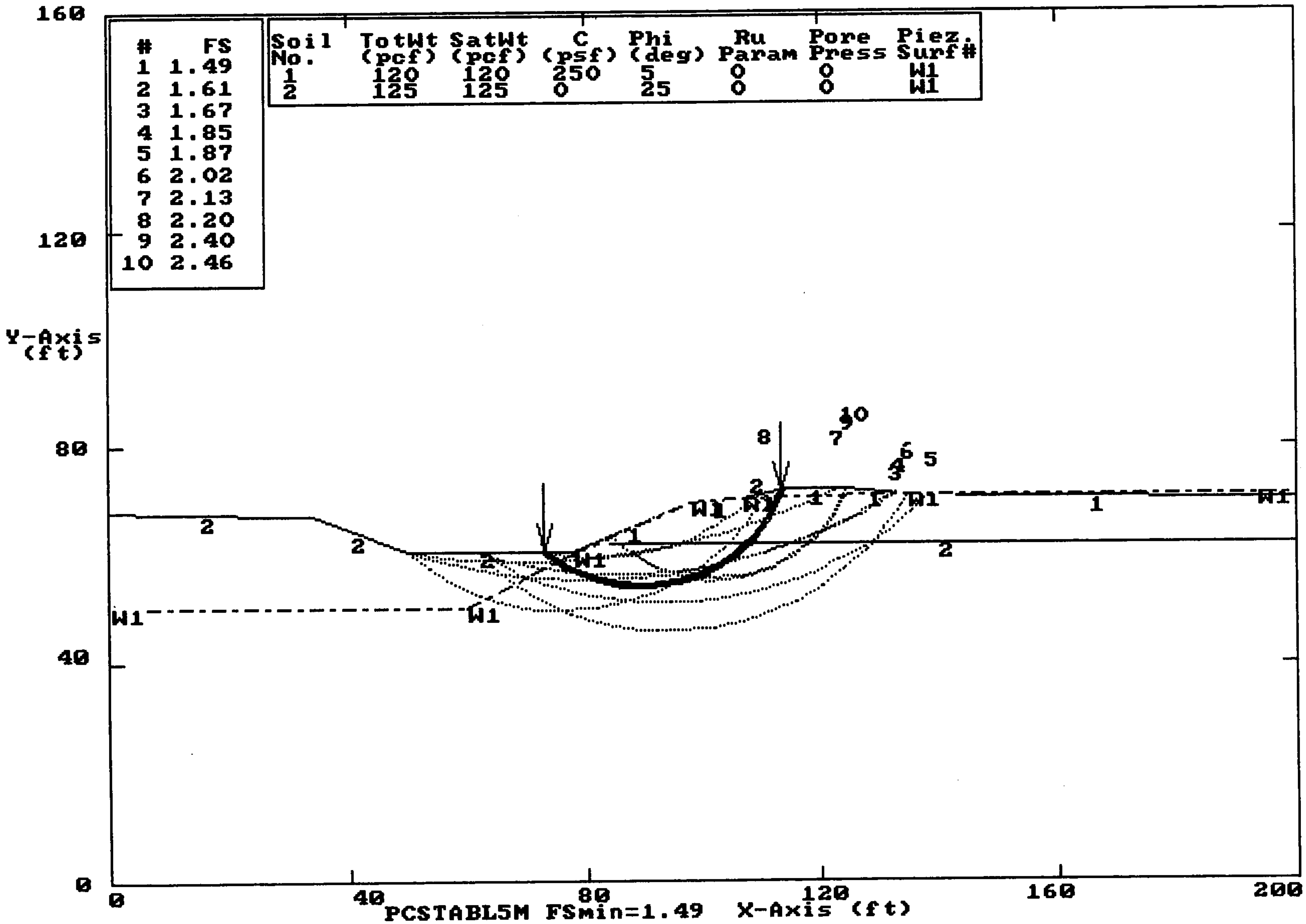
ID	Index Categories: Values	Spec
51243	Discipline: Civil DocType: Specifications	01270A

The geotech report recommends adding unit price contingency items if slope stability problems occur. This is not reflect in the contract documents. Revise.
Submitted by Michael Stello (410-962-4314) on 13-May-02.

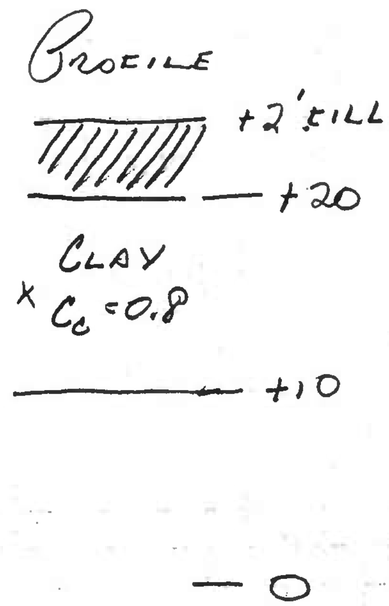
New Evaluation: ○ Concur ◉ Non-Concur ○ For Information Only ○ Check and Resolve
☐ Scope Impact ☐ Cost Impact ☐ Schedule Impact

Attachment: instructions Browse... Add

Berm Perimeter Cross Section 4R Sheet No. 3 (with ravine fill to +10.5)
Ten Most Critical. C:122PM24.PLT By: Frank Grefsheim 06-10-02 10:10am



use LL=100 for compressible subsoils



$C_c = 0.009\,(LL-10)$

$= 0.81$ 2   4   use $e_0 = 1.0$

$p_0 = 5\,(125) = 625$

$\Delta p = 2\,(130) = 260 \quad 520$

$p_f = \quad 885 \quad 1145$

$$S = \left\{\frac{p_f}{p_0}\right\} \frac{C_c}{1+e_0}\, H = \left\{\frac{885}{625}\right\} \frac{0.81}{1+1}\,(10)(12)$$

$S_2 = 7.34$ inches

$$S_4 = \left\{\frac{1145}{625}\right\} \frac{0.81}{1+1}\,(10)(12) = 12.78 \text{ inches}$$

TIME ESTIMATE

use $C_v = 0.02\ ft^2/day$, $H = 5'$

$$t_{90} = \frac{T_{90}\, H^2}{C_v} = \frac{0.85\,(5)^2\ ft^2\ day}{0.02\ ft^2} = 1062 \text{ day}$$

say 6 to 12 inches occurring over an extended time period exceeding 2 years

22923 Quicksilver Drive, Suite 117
Sterling, VA 20166
Tel: (703) 996-0123
Fax: (703) 996-0124

Froehling & Robertson, INC.

Fax

To:	Ms. Michele Monde	**From:**	Franklin Grefsheim
Fax:	(410) 424-2300	**Pages:**	2
Phone:	(410) 424-2317	**Date:**	June 14, 2002
Re:	Hart Miller Island	**CC:**	

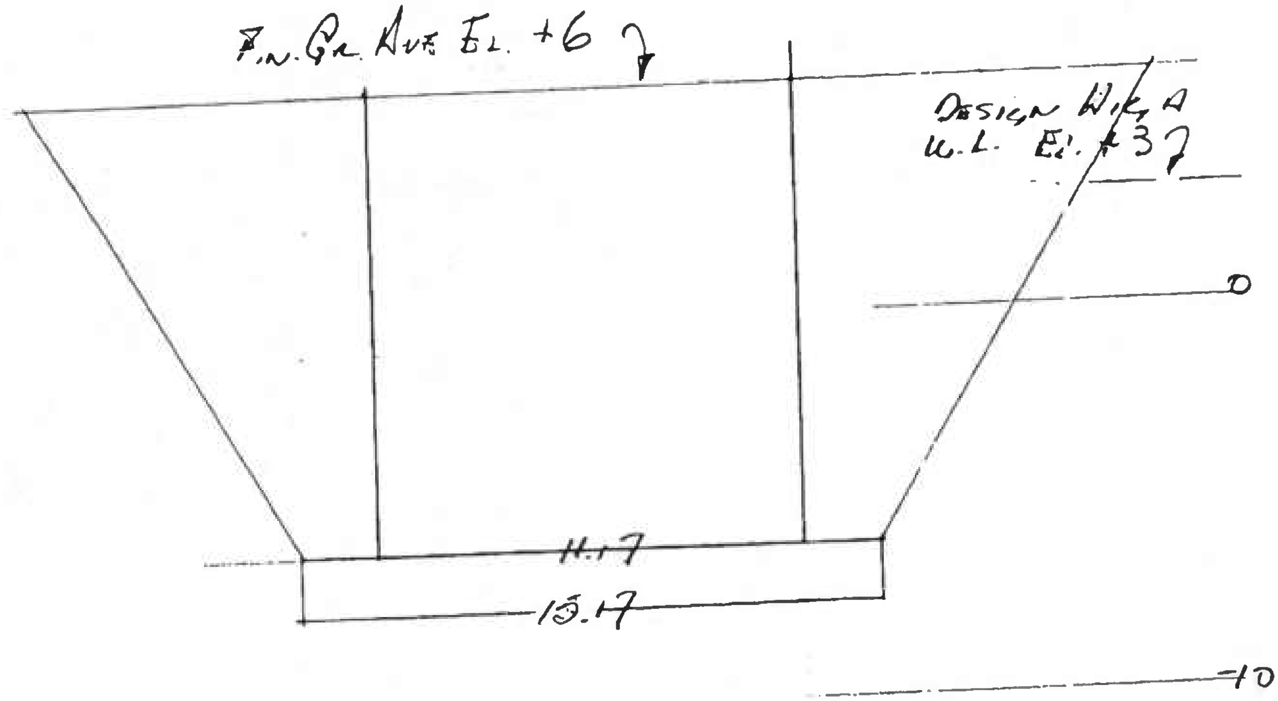
☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Our calculations regarding analysis for the referenced proposed pump station are attached.

These calculations for the revised pump station at higher elevation are based on updated structural load and final slab base elevation data. The resulting factor of safety value is increased from our letter dated June 10, 2002, primarily because of the higher final subgrade of El -7.5 and the increased pump station dead load of 182 kips. Calculations for our recent letter were based on a subgrade of El -10 and a dead load value of 100 kips.

F:\Branch72\Branch Misc\Other Branchs Projects\68 Projects\Fax061402.doc

C68-1224 Pump Station



A. Soil Wedge

$$A_{ave} = \frac{A_1 + A_2}{2} = \frac{15.17^2 + 29^2}{2} = 535 \, \square'$$

$$h = 12' \quad V_{TOTAL} = 535 \times 12 = 6420 \, ft^3$$

$$V_{PUMP} = 11.17^2 \times 12 = 1497$$

$$V_{annular\ wedge} = 4923 \, ft^3$$

$$\text{wedge download} = 4923(.0624) = 307^K$$

$$\text{pump station DL} = 182^K$$

B. TOTAL DOWNLOAD $= 489^K$

C. Uplift

$$= 11.17^2 \times 9 \times .0624 = 70^K$$

D. Factor of safety, $FS = \frac{489}{70} \approx 7$

APPENDIX B

HEC 1 ANALYSIS
CULVERT COMPUTATIONS

HEC-1 Model

```
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*         SEPTEMBER 1990                *
*           VERSION 4.0                 *
*                                       *
*  RUN DATE  03/21/2002  TIME  10:35:14 *
*                                       *
*****************************************

*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*         (916) 756-1104                *
*                                       *
*****************************************


          X     X  XXXXXXX   XXXXX         X
          X     X  X        X     X       XX
          X     X  X        X              X
          XXXXXXX  XXXX     X       XXXXX  X
          X     X  X        X              X
          X     X  X        X     X        X
          X     X  XXXXXXX   XXXXX        XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


                                    HEC-1 INPUT                                            PAGE  1
1
 LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   1       ID   HART MILLER ISLAND
   2       ID   100-YR STORM, 24 HR DURATION
   3       ID   30 MIN TIME OF CONCENTRATION (18 min lag time)
   4       IT      15 20MAR02    0000      300
   5       IN      30 20MAR02    0000
   6       IO       0

   7       KK     CP A
   8       KM   ENTIRE WATERSHED (229 ACRES)
   9       KO                2
  10       BA    0.36
  11       PC       0     .04     .08     .12     .16    .205     .25    .295     .34    .398
  12       PC    .455    .513     .57    .635      .7    .775     .85     .94    1.04    1.16
  13       PC    1.29    1.45    1.67    2.01    4.74    5.22    5.48    5.67    5.82    5.93
  14       PC    6.04    6.14    6.25    6.31    6.38    6.44    6.51    6.57    6.63    6.70
  15       PC    6.76    6.80    6.85    6.89    6.93    6.97    7.02    7.06     7.1
  16       LS            99.0
  17       UD     0.3

  18       KK    STORG
  19       KM    STORAGE ROUTING
  20       KO                2
  21       RS       1    ELEV    19.0
  22       SV     0.0     6.8    31.3    74.5   136.6   220.3   319.8    428.0   541.1
  23       SE    17.0    17.5    18.0    18.5    19.0    19.5    20.0    20.5    21.0
  24       SS    19.0    10.5     3.1     1.5
  25       ZZ
```


```
1*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*         SEPTEMBER 1990                *
*           VERSION 4.0                 *
*                                       *
*  RUN DATE  03/21/2002  TIME  10:35:14 *
*                                       *
*****************************************

*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*        609 SECOND STREET              *
*     DAVIS, CALIFORNIA 95616           *
*         (916) 756-1104                *
*                                       *
*****************************************
```


```
                      HART MILLER ISLAND
                      100-YR STORM, 24 HR DURATION
                      30 MIN TIME OF CONCENTRATION (18 min lag time)

  6 IO          OUTPUT CONTROL VARIABLES
                      IPRNT           0  PRINT CONTROL
                      IPLOT           0  PLOT CONTROL
                      QSCAL          0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                       NMIN          15  MINUTES IN COMPUTATION INTERVAL
                      IDATE     20MAR 2  STARTING DATE
                      ITIME        0000  STARTING TIME
                         NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE     23MAR 2  ENDING DATE
                     NDTIME        0245  ENDING TIME
                      ICENT          19  CENTURY MARK

                 COMPUTATION INTERVAL    .25 HOURS
                      TOTAL TIME BASE  74.75 HOURS

    ENGLISH UNITS
```

```
          DRAINAGE AREA             SQUARE MILES
          PRECIPITATION OEPTH       INCHES
          LENGTN, ELEVATION         FEET
          FLOW                      CUBIC FEET PER SECOND
          STORAGE VOLUME            ACRE-FEET
          SURFACE AREA              ACRES
          TEMPERATURE               DEGREES FAHRENHEIT

 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

         **************
         *            *
 7 KK    *    CP A    *
         *            *
         **************
                   ENTIRE WATERSHED (229 ACRES)

 9 KO          OUTPUT CONTROL VARIABLES
                     IPRNT          0  PRINT CONTROL
                     IPLOT          2  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

 5 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          30  TIME INTERVAL IN MINUTES
                    JXDATE     20MAR 2  STARTING DATE
                    JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

10 BA          SUBBASIN CHARACTERISTICS
                     TAREA        .36  SUBBASIN AREA

               PRECIPITATION DATA

10 PB                STORM       7.10  BASIN TOTAL PRECIPITATION

10 PI            INCREMENTAL PRECIPITATION PATTERN
                   .02      .02      .02      .02      .02      .02      .02      .02      .02      .02
                   .02      .02      .02      .02      .02      .02      .03      .03      .03      .03
                   .03      .03      .03      .03      .03      .03      .03      .03      .04      .04
                   .04      .04      .05      .04      .05      .05      .06      .06      .07      .06
                   .08      .08      .11      .11      .17      .17     1.37     1.36      .24      .24
                   .13      .13      .10      .09      .08      .07      .05      .05      .06      .05
                   .05      .05      .06      .05      .03      .03      .04      .03      .03      .03
                   .04      .03      .03      .03      .03      .03      .03      .03      .03      .03
                   .02      .02      .03      .02      .02      .02      .02      .02      .02      .02
                   .03      .03      .02      .02      .02      .02

16 LS          SCS LOSS RATE
                     STRTL        .02  INITIAL ABSTRACTION
                    CRVNBR      99.00  CURVE NUMBER
                     RTIMP        .00  PERCENT IMPERVIOUS AREA

17 UD          SCS DIMENSIONLESS UNITGRAPH
                      TLAG        .30  LAG
                                                      ***

ARNING *** TIME INTERVAL IS GREATER THAN .29*LAG

                                                 UNIT HYDROGRAPH
                                              8 END-OF-PERIOD ORDINATES
           263.      389.      171.       66.       25.       10.       4.       1.

*****************************************************************************************************************

                                           HYDROGRAPN AT STATION     CP A

*****************************************************************************************************************
```

DA MON NRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA MON HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
20 MAR 0000	1	.00	.00	.00	0.	*	21 MAR 1330	151	.00	.00	.00	0.
20 MAR 0015	2	.02	.02	.00	0.	*	21 MAR 1345	152	.00	.00	.00	0.
20 MAR 0030	3	.02	.02	.00	1.	*	21 MAR 1400	153	.00	.00	.00	0.
20 MAR 0045	4	.02	.01	.01	3.	*	21 MAR 1415	154	.00	.00	.00	0.
20 MAR 0100	5	.02	.01	.01	7.	*	21 MAR 1430	155	.00	.00	.00	0.
20 MAR 0115	6	.02	.01	.01	9.	*	21 MAR 1445	156	.00	.00	.00	0.
20 MAR 0130	7	.02	.01	.01	11.	*	21 MAR 1500	157	.00	.00	.00	0.
20 MAR 0145	8	.02	.00	.02	13.	*	21 MAR 1515	158	.00	.00	.00	0.
20 MAR 0200	9	.02	.00	.02	14.	*	21 MAR 1530	159	.00	.00	.00	0.
20 MAR 0215	10	.02	.00	.02	15.	*	21 MAR 1545	160	.00	.00	.00	0.
20 MAR 0230	11	.02	.00	.02	17.	*	21 MAR 1600	161	.00	.00	.00	0.
20 MAR 0245	12	.02	.00	.02	18.	*	21 MAR 1615	162	.00	.00	.00	0.
20 MAR 0300	13	.02	.00	.02	18.	*	21 MAR 1630	163	.00	.00	.00	0.
20 MAR 0315	14	.02	.00	.02	19.	*	21 MAR 1645	164	.00	.00	.00	0.
20 MAR 0330	15	.02	.00	.02	19.	*	21 MAR 1700	165	.00	.00	.00	0.
20 MAR 0345	16	.02	.00	.02	19.	*	21 MAR 1715	166	.00	.00	.00	0.
20 MAR 0400	17	.02	.00	.02	19.	*	21 MAR 1730	167	.00	.00	.00	0.
20 MAR 0415	18	.03	.00	.03	21.	*	21 MAR 1745	168	.00	.00	.00	0.
20 MAR 0430	19	.03	.00	.03	24.	*	21 MAR 1800	169	.00	.00	.00	0.
20 MAR 0445	20	.03	.00	.03	25.	*	21 MAR 1815	170	.00	.00	.00	0.
20 MAR 0500	21	.03	.00	.03	25.	*	21 MAR 1830	171	.00	.00	.00	0.
20 MAR 0515	22	.03	.00	.03	26.	*	21 MAR 1845	172	.00	.00	.00	0.
20 MAR 0530	23	.03	.00	.03	26.	*	21 MAR 1900	173	.00	.00	.00	0.
20 MAR 0545	24	.03	.00	.03	26.	*	21 MAR 1915	174	.00	.00	.00	0.
20 MAR 0600	25	.03	.00	.03	26.	*	21 MAR 1930	175	.00	.00	.00	0.
20 MAR 0615	26	.03	.00	.03	27.	*	21 MAR 1945	176	.00	.00	.00	0.

20 MAR 0630	27	.03	.00	.03	28.	*
20 MAR 0645	28	.03	.00	.03	29.	*
20 MAR 0700	29	.03	.00	.03	29.	*
20 MAR 0715	30	.04	.00	.04	31.	*
20 MAR 0730	31	.04	.00	.04	33.	*
20 MAR 0745	32	.04	.00	.04	34.	*
20 MAR 0800	33	.04	.00	.04	34.	*
20 MAR 0815	34	.05	.00	.04	36.	*
20 MAR 0830	35	.04	.00	.04	39.	*
20 MAR 0845	36	.05	.00	.05	42.	*
20 MAR 0900	37	.05	.00	.05	44.	*
20 MAR 0915	38	.06	.00	.06	48.	*
20 MAR 0930	39	.06	.00	.06	52.	*
20 MAR 0945	40	.07	.00	.06	56.	*
20 MAR 1000	41	.06	.00	.06	58.	*
20 MAR 1015	42	.08	.00	.08	63.	*
20 MAR 1030	43	.08	.00	.08	70.	*
20 MAR 1045	44	.11	.00	.11	80.	*
20 MAR 1100	45	.11	.00	.11	93.	*
20 MAR 1115	46	.17	.00	.17	114.	*
20 MAR 1130	47	.17	.00	.17	140.	*
20 MAR 1145	48	1.37	.00	1.36	464.	*
20 MAR 1200	49	1.36	.00	1.36	933.	*
20 MAR 1215	50	.24	.00	.24	844.	*
20 MAR 1230	51	.24	.00	.24	486.	*
20 MAR 1245	52	.13	.00	.13	296.	*
20 MAR 1300	53	.13	.00	.13	190.	*
20 MAR 1315	54	.10	.00	.09	139.	*
20 MAR 1330	55	.09	.00	.09	108.	*
20 MAR 1345	56	.08	.00	.07	90.	*
20 MAR 1400	57	.07	.00	.07	77.	*
20 MAR 1415	58	.05	.00	.05	67.	*
20 MAR 1430	59	.05	.00	.05	58.	*
20 MAR 1445	60	.06	.00	.05	54.	*
20 MAR 1500	61	.05	.00	.05	52.	*
20 MAR 1515	62	.05	.00	.05	50.	*
20 MAR 1530	63	.05	.00	.05	48.	*
20 MAR 1545	64	.06	.00	.05	48.	*
20 MAR 1600	65	.05	.00	.05	50.	*
20 MAR 1615	66	.03	.00	.03	44.	*
20 MAR 1630	67	.03	.00	.03	35.	*
20 MAR 1645	68	.04	.00	.03	32.	*
20 MAR 1700	69	.03	.00	.03	32.	*
20 MAR 1715	70	.03	.00	.03	31.	*
20 MAR 1730	71	.03	.00	.03	29.	*
20 MAR 1745	72	.04	.00	.03	30.	*
20 MAR 1800	73	.03	.00	.03	31.	*
20 MAR 1815	74	.03	.00	.03	31.	*
20 MAR 1830	75	.03	.00	.03	29.	*
20 MAR 1845	76	.03	.00	.03	28.	*
20 MAR 1900	77	.03	.00	.03	28.	*
20 MAR 1915	78	.03	.00	.03	29.	*
20 MAR 1930	79	.03	.00	.03	31.	*
20 MAR 1945	80	.03	.00	.03	31.	*
20 MAR 2000	81	.03	.00	.03	29.	*
20 MAR 2015	82	.02	.00	.02	26.	*
20 MAR 2030	83	.02	.00	.02	22.	*
20 MAR 2045	84	.03	.00	.02	21.	*
20 MAR 2100	85	.02	.00	.02	22.	*
20 MAR 2115	86	.02	.00	.02	22.	*
20 MAR 2130	87	.02	.00	.02	20.	*
20 MAR 2145	88	.02	.00	.02	19.	*
20 MAR 2200	89	.02	.00	.02	19.	*
20 MAR 2215	90	.02	.00	.02	19.	*
20 MAR 2230	91	.02	.00	.02	19.	*
20 MAR 2245	92	.03	.00	.02	20.	*
20 MAR 2300	93	.03	.00	.02	22.	*
20 MAR 2315	94	.02	.00	.02	21.	*
20 MAR 2330	95	.02	.00	.02	20.	*
20 MAR 2345	96	.02	.00	.02	19.	*
21 MAR 0000	97	.02	.00	.02	19.	*
21 MAR 0015	98	.00	.00	.00	13.	*
21 MAR 0030	99	.00	.00	.00	6.	*
21 MAR 0045	100	.00	.00	.00	2.	*
21 MAR 0100	101	.00	.00	.00	1.	*
21 MAR 0115	102	.00	.00	.00	0.	*
21 MAR 0130	103	.00	.00	.00	0.	*
21 MAR 0145	104	.00	.00	.00	0.	*
21 MAR 0200	105	.00	.00	.00	0.	*
21 MAR 0215	106	.00	.00	.00	0.	*
21 MAR 0230	107	.00	.00	.00	0.	*
21 MAR 0245	108	.00	.00	.00	0.	*
21 MAR 0300	109	.00	.00	.00	0.	*
21 MAR 0315	110	.00	.00	.00	0.	*
21 MAR 0330	111	.00	.00	.00	0.	*
21 MAR 0345	112	.00	.00	.00	0.	*
21 MAR 0400	113	.00	.00	.00	0.	*
21 MAR 0415	114	.00	.00	.00	0.	*
21 MAR 0430	115	.00	.00	.00	0.	*
21 MAR 0445	116	.00	.00	.00	0.	*
21 MAR 0500	117	.00	.00	.00	0.	*
21 MAR 0515	118	.00	.00	.00	0.	*
21 MAR 0530	119	.00	.00	.00	0.	*
21 MAR 0545	120	.00	.00	.00	0.	*
21 MAR 0600	121	.00	.00	.00	0.	*
21 MAR 0615	122	.00	.00	.00	0.	*
21 MAR 0630	123	.00	.00	.00	0.	*
21 MAR 0645	124	.00	.00	.00	0.	*
21 MAR 0700	125	.00	.00	.00	0.	*
21 MAR 0715	126	.00	.00	.00	0.	*
21 MAR 0730	127	.00	.00	.00	0.	*

21 MAR 2000	177	.00	.00	.00	0.
21 MAR 2015	178	.00	.00	.00	0.
21 MAR 2030	179	.00	.00	.00	0.
21 MAR 2045	180	.00	.00	.00	0.
21 MAR 2100	181	.00	.00	.00	0.
21 MAR 2115	182	.00	.00	.00	0.
21 MAR 2130	183	.00	.00	.00	0.
21 MAR 2145	184	.00	.00	.00	0.
21 MAR 2200	185	.00	.00	.00	0.
21 MAR 2215	186	.00	.00	.00	0.
21 MAR 2230	187	.00	.00	.00	0.
21 MAR 2245	188	.00	.00	.00	0.
21 MAR 2300	189	.00	.00	.00	0.
21 MAR 2315	190	.00	.00	.00	0.
21 MAR 2330	191	.00	.00	.00	0.
21 MAR 2345	192	.00	.00	.00	0.
22 MAR 0000	193	.00	.00	.00	0.
22 MAR 0015	194	.00	.00	.00	0.
22 MAR 0030	195	.00	.00	.00	0.
22 MAR 0045	196	.00	.00	.00	0.
22 MAR 0100	197	.00	.00	.00	0.
22 MAR 0115	198	.00	.00	.00	0.
22 MAR 0130	199	.00	.00	.00	0.
22 MAR 0145	200	.00	.00	.00	0.
22 MAR 0200	201	.00	.00	.00	0.
22 MAR 0215	202	.00	.00	.00	0.
22 MAR 0230	203	.00	.00	.00	0.
22 MAR 0245	204	.00	.00	.00	0.
22 MAR 0300	205	.00	.00	.00	0.
22 MAR 0315	206	.00	.00	.00	0.
22 MAR 0330	207	.00	.00	.00	0.
22 MAR 0345	208	.00	.00	.00	0.
22 MAR 0400	209	.00	.00	.00	0.
22 MAR 0415	210	.00	.00	.00	0.
22 MAR 0430	211	.00	.00	.00	0.
22 MAR 0445	212	.00	.00	.00	0.
22 MAR 0500	213	.00	.00	.00	0.
22 MAR 0515	214	.00	.00	.00	0.
22 MAR 0530	215	.00	.00	.00	0.
22 MAR 0545	216	.00	.00	.00	0.
22 MAR 0600	217	.00	.00	.00	0.
22 MAR 0615	218	.00	.00	.00	0.
22 MAR 0630	219	.00	.00	.00	0.
22 MAR 0645	220	.00	.00	.00	0.
22 MAR 0700	221	.00	.00	.00	0.
22 MAR 0715	222	.00	.00	.00	0.
22 MAR 0730	223	.00	.00	.00	0.
22 MAR 0745	224	.00	.00	.00	0.
22 MAR 0800	225	.00	.00	.00	0.
22 MAR 0815	226	.00	.00	.00	0.
22 MAR 0830	227	.00	.00	.00	0.
22 MAR 0845	228	.00	.00	.00	0.
22 MAR 0900	229	.00	.00	.00	0.
22 MAR 0915	230	.00	.00	.00	0.
22 MAR 0930	231	.00	.00	.00	0.
22 MAR 0945	232	.00	.00	.00	0.
22 MAR 1000	233	.00	.00	.00	0.
22 MAR 1015	234	.00	.00	.00	0.
22 MAR 1030	235	.00	.00	.00	0.
22 MAR 1045	236	.00	.00	.00	0.
22 MAR 1100	237	.00	.00	.00	0.
22 MAR 1115	238	.00	.00	.00	0.
22 MAR 1130	239	.00	.00	.00	0.
22 MAR 1145	240	.00	.00	.00	0.
22 MAR 1200	241	.00	.00	.00	0.
22 MAR 1215	242	.00	.00	.00	0.
22 MAR 1230	243	.00	.00	.00	0.
22 MAR 1245	244	.00	.00	.00	0.
22 MAR 1300	245	.00	.00	.00	0.
22 MAR 1315	246	.00	.00	.00	0.
22 MAR 1330	247	.00	.00	.00	0.
22 MAR 1345	248	.00	.00	.00	0.
22 MAR 1400	249	.00	.00	.00	0.
22 MAR 1415	250	.00	.00	.00	0.
22 MAR 1430	251	.00	.00	.00	0.
22 MAR 1445	252	.00	.00	.00	0.
22 MAR 1500	253	.00	.00	.00	0.
22 MAR 1515	254	.00	.00	.00	0.
22 MAR 1530	255	.00	.00	.00	0.
22 MAR 1545	256	.00	.00	.00	0.
22 MAR 1600	257	.00	.00	.00	0.
22 MAR 1615	258	.00	.00	.00	0.
22 MAR 1630	259	.00	.00	.00	0.
22 MAR 1645	260	.00	.00	.00	0.
22 MAR 1700	261	.00	.00	.00	0.
22 MAR 1715	262	.00	.00	.00	0.
22 MAR 1730	263	.00	.00	.00	0.
22 MAR 1745	264	.00	.00	.00	0.
22 MAR 1800	265	.00	.00	.00	0.
22 MAR 1815	266	.00	.00	.00	0.
22 MAR 1830	267	.00	.00	.00	0.
22 MAR 1845	268	.00	.00	.00	0.
22 MAR 1900	269	.00	.00	.00	0.
22 MAR 1915	270	.00	.00	.00	0.
22 MAR 1930	271	.00	.00	.00	0.
22 MAR 1945	272	.00	.00	.00	0.
22 MAR 2000	273	.00	.00	.00	0.
22 MAR 2015	274	.00	.00	.00	0.
22 MAR 2030	275	.00	.00	.00	0.
22 MAR 2045	276	.00	.00	.00	0.
22 MAR 2100	277	.00	.00	.00	0.

21	MAR	0745	128	.00	.00	.00	0.	*	22	MAR	2115	278	.00	.00	.00	0.
21	MAR	0800	129	.00	.00	.00	0.	*	22	MAR	2130	279	.00	.00	.00	0.
21	MAR	0815	130	.00	.00	.00	0.	*	22	MAR	2145	280	.00	.00	.00	0.
21	MAR	0830	131	.00	.00	.00	0.	*	22	MAR	2200	281	.00	.00	.00	0.
21	MAR	0845	132	.00	.00	.00	0.	*	22	MAR	2215	282	.00	.00	.00	0.
21	MAR	0900	133	.00	.00	.00	0.	*	22	MAR	2230	283	.00	.00	.00	0.
21	MAR	0915	134	.00	.00	.00	0.	*	22	MAR	2245	284	.00	.00	.00	0.
21	MAR	0930	135	.00	.00	.00	0.	*	22	MAR	2300	285	.00	.00	.00	0.
21	MAR	0945	136	.00	.00	.00	0.	*	22	MAR	2315	286	.00	.00	.00	0.
21	MAR	1000	137	.00	.00	.00	0.	*	22	MAR	2330	287	.00	.00	.00	0.
21	MAR	1015	138	.00	.00	.00	0.	*	22	MAR	2345	288	.00	.00	.00	0.
21	MAR	1030	139	.00	.00	.00	0.	*	23	MAR	0000	289	.00	.00	.00	0.
21	MAR	1045	140	.00	.00	.00	0.	*	23	MAR	0015	290	.00	.00	.00	0.
21	MAR	1100	141	.00	.00	.00	0.	*	23	MAR	0030	291	.00	.00	.00	0.
21	MAR	1115	142	.00	.00	.00	0.	*	23	MAR	0045	292	.00	.00	.00	0.
21	MAR	1130	143	.00	.00	.00	0.	*	23	MAR	0100	293	.00	.00	.00	0.
21	MAR	1145	144	.00	.00	.00	0.	*	23	MAR	0115	294	.00	.00	.00	0.
21	MAR	1200	145	.00	.00	.00	0.	*	23	MAR	0130	295	.00	.00	.00	0.
21	MAR	1215	146	.00	.00	.00	0.	*	23	MAR	0145	296	.00	.00	.00	0.
21	MAR	1230	147	.00	.00	.00	0.	*	23	MAR	0200	297	.00	.00	.00	0.
21	MAR	1245	148	.00	.00	.00	0.	*	23	MAR	0215	298	.00	.00	.00	0.
21	MAR	1300	149	.00	.00	.00	0.	*	23	MAR	0230	299	.00	.00	.00	0.
21	MAR	1315	150	.00	.00	.00	0.	*	23	MAR	0245	300	.00	.00	.00	0.

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*********************************************************************************************************************************

TOTAL RAINFALL =    7.10, TOTAL LOSS =     .12, TOTAL EXCESS =    6.98

PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR        24-HR       72-HR      74.75-HR
  (CFS)        (HR)
                           (CFS)
   933.       22.00                    193.         68.         23.         22.
                         (INCHES)     4.986       6.975       6.980       6.980
                          (AC-FT)       96.        134.        134.        134.

                         CUMULATIVE AREA =     .36 SQ MI

                                                         STATION     CP A

                        (O) OUTFLOW
        0.       200.      400.      600.      800.     1000.      0.        0.        0.        0.        0.        0.        0.
                                                                                          (L) PRECIP,   (X) EXCESS
        .0        .0        .0        .0        .0        .0        .0        .0       1.6       1.2        .8        .4        .0
AHRMN PER
00000   10---------.---------.---------.---------.---------.---------.---------.---------.---------.---------.---------.---------.
200015  20         .         .         .         .         .         .         .         .         .         .         .        L.
200030  30         .         .         .         .         .         .         .         .         .         .         .         .
00045   40         .         .         .         .         .         .         .         .         .         .         .         .
00100   50         .         .         .         .         .         .         .         .         .         .         .        L.
00115   60         .         .         .         .         .         .         .         .         .         .         .         .
00130   7.0        .         .         .         .         .         .         .         .         .         .         .        L.
200145  8.0        .         .         .         .         .         .         .         .         .         .         .         .
200200  9.0        .         .         .         .         .         .         .         .         .         .         .        L.
200215 10.0        .         .         .         .         .         .         .         .         .         .         .        L.
00230  11.0. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .L.
00245  12.0        .         .         .         .         .         .         .         .         .         .         .        X.
00300  13.0        .         .         .         .         .         .         .         .         .         .         .        X.
00315  14.0        .         .         .         .         .         .         .         .         .         .         .        X.
200330 15.0        .         .         .         .         .         .         .         .         .         .         .        X.
200345 16.0        .         .         .         .         .         .         .         .         .         .         .        X.
00400  17.0        .         .         .         .         .         .         .         .         .         .         .        X.
00415  18.0        .         .         .         .         .         .         .         .         .         .         .        X.
00430  19.0        .         .         .         .         .         .         .         .         .         .         .        X.
00445  20.0        .         .         .         .         .         .         .         .         .         .         .        X.
200500 21.0. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .X.
200515 22.0        .         .         .         .         .         .         .         .         .         .         .        X.
200530 23.0        .         .         .         .         .         .         .         .         .         .         .        X.
00545  24.0        .         .         .         .         .         .         .         .         .         .         .        X.
00600  25.0        .         .         .         .         .         .         .         .         .         .         .        X.
00615  26.0        .         .         .         .         .         .         .         .         .         .         .        X.
200630 27.0        .         .         .         .         .         .         .         .         .         .         .        X.
200645 28.0        .         .         .         .         .         .         .         .         .         .         .        X.
200700 29.0        .         .         .         .         .         .         .         .         .         .         .        X.
200715 30. O       .         .         .         .         .         .         .         .         .         .         .        X.
200730 31. O . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .X.
200745 32. O       .         .         .         .         .         .         .         .         .         .         .        X.
200800 33. O       .         .         .         .         .         .         .         .         .         .         .        X.
200815 34. O       .         .         .         .         .         .         .         .         .         .         .        X.
200830 35. O       .         .         .         .         .         .         .         .         .         .         .        X.
200845 36. O       .         .         .         .         .         .         .         .         .         .         .        X.
200900 37. O       .         .         .         .         .         .         .         .         .         .         .       LX.
200915 38. O       .         .         .         .         .         .         .         .         .         .         .        X.
200930 39.  O      .         .         .         .         .         .         .         .         .         .         .       XX.
200945 40.  O      .         .         .         .         .         .         .         .         .         .         .       XX.
201000 41. .O. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .XX.
201015 42.  O      .         .         .         .         .         .         .         .         .         .         .       XX.
201030 43.  O      .         .         .         .         .         .         .         .         .         .         .      XXX.
201045 44.   O     .         .         .         .         .         .         .         .         .         .         .      XXX.
201100 45.    O    .         .         .         .         .         .         .         .         .         .         .     XXXX.
201115 46.     O   .         .         .         .         .         .         .         .         .         .         .     XXXX.
201130 47.      O  .         .         .         .         .         .         .         .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.
201145 48.         .         . O       .         .         .         .         .         .XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.
201200 49.         .         .         .         .    O    .         .         .         .         .         .         .   XXXXXX.
201215 50.         .         .         .         . O       .         .         .         .         .         .         .  XXXXXXX.
201230 51. . . . . . . . . . . .O. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .XXX.
201245 52.         .    O    .         .         .         .         .         .         .         .         .         .      XXX.
201300 53.         O         .         .         .         .         .         .         .         .         .         .       XX.
201315 54.      O  .         .         .         .         .         .         .         .         .         .         .       XX.
201330 55.    O    .         .         .         .         .         .         .         .         .         .         .       XX.
201345 56.   O     .         .         .         .         .         .         .         .         .         .         .       XX.
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                                                              XX.
400   57.   O                                                 X.
201415  58.  O                                                X.
201430  59.  O                                                X.
201445  60.  O                                                X.
500   61.  O                                                  X.
515   62.  O                                                  X.
530   63. O                                                   X.
201545  64. O                                                 X.
201600  65. O                                                 X.
201615  66. O                                                 X.
630   67. O                                                   X.
645   68. O                                                   X.
700   69. O                                                   X.
01715  70. O                                                  X.
201730  71.O                                                  X.
201745  72.O                                                  X.
800   73. O                                                   X.
815   74. O                                                   X.
830   75.O                                                    X.
845   76.O                                                    X.
201900  77.O                                                  X.
201915  78.O                                                  X.
201930  79. O                                                 X.
1945  80. O                                                   X.
2000  81.O
2015  82.O
202030  83.O                                                  X.
202045  84.O                                                  X.
202100  85.O
2115  86.O
2130  87.O
2145  88.O
202200  89.O
202215  90.O
202230  91.O                                                  X.
202245  92.O                                                  X.
2300  93.O
2315  94.O
2330  95.O
202345  96.O
210000  97.O
210015  98.O
0030  990
0045 1000
0100 1010
210115 1020
210130 1030
210145 1040
0200 1050
0215 1060
0230 1070
0245 1080
210300 1090
210315 1100
210330 1110
10345 1120
10400 1130
10415 1140
210430 1150
210445 1160
210500 1170
10515 1180
10530 1190
10545 1200
210600 1210
210615 1220
210630 1230
10645 1240
10700 1250
10715 1260
10730 1270
210745 1280
210800 1290
210815 1300
10830 1310
10845 1320
10900 1330
210915 1340
210930 1350
210945 1360
211000 1370
211015 1380
211030 1390
211045 1400
211100 1410
211115 1420
211130 1430
211145 1440
211200 1450
211215 1460
211230 1470
211245 1480
211300 1490
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211330 1510
211345 1520
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211415 1540
211430 1550
211445 1560
211500 1570
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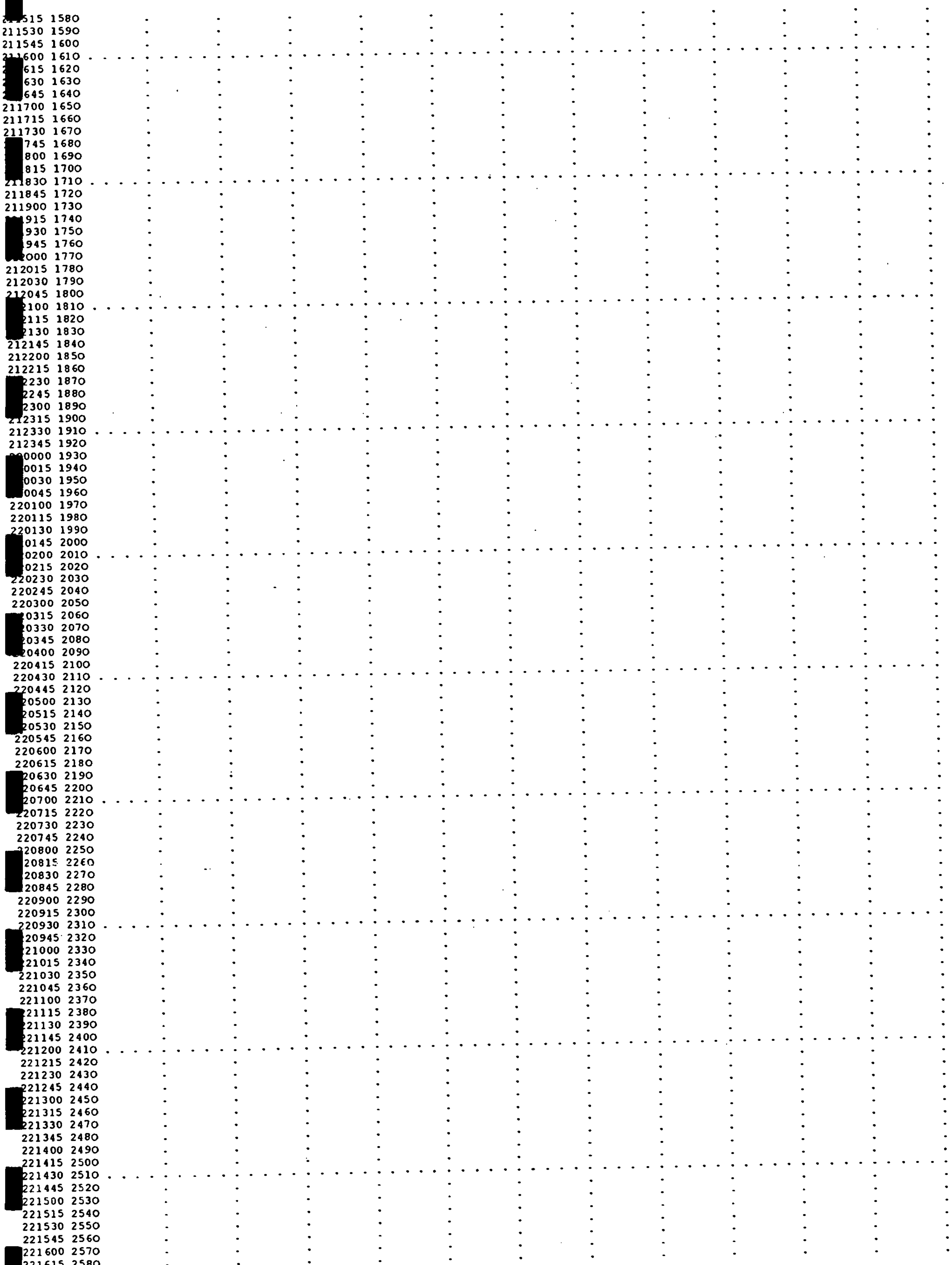

515 1580
211530 1590
211545 1600
600 1610
615 1620
630 1630
645 1640
211700 1650
211715 1660
211730 1670
745 1680
800 1690
815 1700
11830 1710
211845 1720
211900 1730
915 1740
930 1750
945 1760
000 1770
212015 1780
212030 1790
212045 1800
2100 1810
2115 1820
2130 1830
212145 1840
212200 1850
212215 1860
2230 1870
2245 1880
2300 1890
12315 1900
212330 1910
212345 1920
0000 1930
0015 1940
0030 1950
0045 1960
220100 1970
220115 1980
220130 1990
0145 2000
0200 2010
0215 2020
20230 2030
220245 2040
220300 2050
0315 2060
0330 2070
0345 2080
0400 2090
220415 2100
220430 2110
20445 2120
20500 2130
20515 2140
20530 2150
220545 2160
220600 2170
220615 2180
20630 2190
20645 2200
20700 2210
20715 2220
220730 2230
220745 2240
20800 2250
20815 2260
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20945 2320
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221045 2360
221100 2370
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21145 2400
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21245 2440
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221400 2490
221415 2500
221430 2510
221445 2520
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221530 2550
221545 2560
221600 2570
221615 2580

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21630 2590
21645 2600
21700 2610
   15 2620
   30 2630
   45 2640
   00 2650
221815 2660
221830 2670
221845 2680
   900 2690
   915 2700
   930 2710
221945 2720
222000 2730
222015 2740
   030 2750
   045 2760
   100 2770
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222130 2790
222145 2800
   200 2810
   215 2820
   230 2830
   245 2840
222300 2850
222315 2860
222330 2870
   345 2880
   000 2890
   015 2900
230030 2910
230045 2920
230100 2930
   115 2940
   130 2950
   145 2960
230200 2970
230215 2980
230230 2990
   245 3000
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

                *************
                *           *
18 KK           *   STORG   *
                *           *
                *************
                           STORAGE ROUTING

20 KO           OUTPUT CONTROL VARIABLES
                       IPRNT          0  PRINT CONTROL
                       IPLOT          2  PLOT CONTROL
                       QSCAL         0.  HYDROGRAPH PLOT SCALE

                HYDROGRAPH ROUTING DATA

21 RS             STORAGE ROUTING
                       NSTPS          1  NUMBER OF SUBREACHES
                       ITYP        ELEV  TYPE OF INITIAL CONDITION
                       RSVRIC     19.00  INITIAL CONDITION
                       X            .00  WORKING R AND D COEFFICIENT

22 SV              STORAGE        .0     6.8    31.3    74.5   136.060000220.0     .3     9.8   428.0   541.1

23 SE            ELEVATION     17.00   17.50   18.00   18.50   19.00   19.00     .50     .00   20.50   21.00

24 SS             SPILLWAY
                       CREL       19.00  SPILLWAY CREST ELEVATION
                       SPWID      10.50  SPILLWAY WIDTH
                       COQW        3.10  WEIR COEFFICIENT
                       EXPW        1.50  EXPONENT OF HEAD

                                                 ***

                                  COMPUTED OUTFLOW-ELEVATION DATA

   OUTFLOW       .00      .00      .02      .13      .43     1.01     1.97     3.41     5.41     8.08
 ELEVATION     17.00    19.00    19.01    19.02    19.06    19.10    19.15    19.22    19.30    19.40

   OUTFLOW     11.51    15.79    21.01    27.28    34.68    43.32    53.28    64.66    77.56    92.07
 ELEVATION     19.50    19.62    19.75    19.89    20.04    20.21    20.39    20.58    20.78    21.00

                               COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

   STORAGE       .00     6.80    31.30    74.50   397.40   397.90   398.53   399.41   400.55   401.93
   OUTFLOW       .00      .00      .00      .00      .00      .13      .43     1.01     1.97     3.41
 ELEVATION     17.00    17.50    18.00    18.50    19.00    19.02    19.06    19.10    19.15    19.22

   STORAGE    403.57   405.46   407.60   409.99   412.64   415.53   418.68   422.08   425.73   428.00
   OUTFLOW      5.41     8.08    11.51    15.79    21.01    27.28    34.68    43.32    53.28    59.80
 ELEVATION     19.30    19.40    19.50    19.62    19.75    19.89    20.04    20.21    20.39    20.50
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STORAGE	446.15	492.23	541.10
OUTFLOW	64.66	77.56	92.07
ELEVATION	20.58	20.78	21.00

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HYDROGRAPH AT STATION STORG

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DA MON HRMN	ORD	OUTFLOW	STORAGE	STAGE	DA MON HRMN	ORD	OUTFLOW	STORAGE	STAGE	DA MON HRMN	ORD	OUTFLOW	STORAGE	STAGE
20 MAR 0000	1	0.	397.4	19.0	21 MAR 0100	101	64.	444.9	20.6	22 MAR 0200	201	3.	401.4	19.2
20 MAR 0015	2	0.	397.4	19.0	21 MAR 0115	102	64.	443.6	20.6	22 MAR 0215	202	3.	401.4	19.2
20 MAR 0030	3	0.	397.4	19.0	21 MAR 0130	103	64.	442.3	20.6	22 MAR 0230	203	3.	401.3	19.2
20 MAR 0045	4	0.	397.5	19.0	21 MAR 0145	104	63.	441.0	20.6	22 MAR 0245	204	3.	401.2	19.2
20 MAR 0100	5	0.	397.6	19.0	21 MAR 0200	105	63.	439.7	20.6	22 MAR 0300	205	3.	401.2	19.2
20 MAR 0115	6	0.	397.7	19.0	21 MAR 0215	106	63.	438.4	20.5	22 MAR 0315	206	3.	401.1	19.2
20 MAR 0130	7	0.	397.9	19.0	21 MAR 0230	107	62.	437.1	20.5	22 MAR 0330	207	3.	401.1	19.2
20 MAR 0145	8	0.	398.2	19.0	21 MAR 0245	108	62.	435.8	20.5	22 MAR 0345	208	2.	401.0	19.2
20 MAR 0200	9	0.	398.4	19.1	21 MAR 0300	109	62.	434.5	20.5	22 MAR 0400	209	2.	401.0	19.2
20 MAR 0215	10	1.	398.7	19.1	21 MAR 0315	110	61.	433.3	20.5	22 MAR 0415	210	2.	400.9	19.2
20 MAR 0230	11	1.	399.1	19.1	21 MAR 0330	111	61.	432.0	20.5	22 MAR 0430	211	2.	400.9	19.2
20 MAR 0245	12	1.	399.4	19.1	21 MAR 0345	112	61.	430.8	20.5	22 MAR 0445	212	2.	400.8	19.2
20 MAR 0300	13	1.	399.7	19.1	21 MAR 0400	113	60.	429.5	20.5	22 MAR 0500	213	2.	400.8	19.2
20 MAR 0315	14	2.	400.1	19.1	21 MAR 0415	114	60.	428.3	20.5	22 MAR 0515	214	2.	400.7	19.2
20 MAR 0330	15	2.	400.4	19.1	21 MAR 0430	115	57.	427.1	20.5	22 MAR 0530	215	2.	400.7	19.2
20 MAR 0345	16	2.	400.8	19.2	21 MAR 0445	116	54.	425.9	20.4	22 MAR 0545	216	2.	400.7	19.2
20 MAR 0400	17	3.	401.1	19.2	21 MAR 0500	117	51.	424.8	20.3	22 MAR 0600	217	2.	400.6	19.2
20 MAR 0415	18	3.	401.5	19.2	21 MAR 0515	118	48.	423.8	20.3	22 MAR 0615	218	2.	400.6	19.2
20 MAR 0430	19	3.	401.9	19.2	21 MAR 0530	119	45.	422.8	20.2	22 MAR 0630	219	2.	400.5	19.2
20 MAR 0445	20	4.	402.3	19.2	21 MAR 0545	120	43.	421.9	20.2	22 MAR 0645	220	2.	400.5	19.2
20 MAR 0500	21	4.	402.8	19.3	21 MAR 0600	121	41.	421.1	20.2	22 MAR 0700	221	2.	400.5	19.1
20 MAR 0515	22	5.	403.2	19.3	21 MAR 0615	122	39.	420.3	20.1	22 MAR 0715	222	2.	400.4	19.1
20 MAR 0530	23	5.	403.6	19.3	21 MAR 0630	123	37.	419.5	20.1	22 MAR 0730	223	2.	400.4	19.1
20 MAR 0545	24	6.	404.0	19.3	21 MAR 0645	124	35.	418.7	20.0	22 MAR 0745	224	2.	400.3	19.1
20 MAR 0600	25	7.	404.4	19.3	21 MAR 0700	125	33.	418.0	20.0	22 MAR 0800	225	2.	400.3	19.1
20 MAR 0615	26	7.	404.8	19.4	21 MAR 0715	126	32.	417.4	20.0	22 MAR 0815	226	2.	400.3	19.1
20 MAR 0630	27	8.	405.3	19.4	21 MAR 0730	127	30.	416.7	19.9	22 MAR 0830	227	2.	400.2	19.1
20 MAR 0645	28	8.	405.7	19.4	21 MAR 0745	128	29.	416.1	19.9	22 MAR 0845	228	2.	400.2	19.1
20 MAR 0700	29	9.	406.1	19.4	21 MAR 0800	129	27.	415.5	19.9	22 MAR 0900	229	2.	400.2	19.1
20 MAR 0715	30	10.	406.5	19.4	21 MAR 0815	130	26.	415.0	19.9	22 MAR 0915	230	2.	400.1	19.1
20 MAR 0730	31	11.	407.0	19.5	21 MAR 0830	131	25.	414.5	19.8	22 MAR 0930	231	2.	400.1	19.1
20 MAR 0745	32	11.	407.4	19.5	21 MAR 0845	132	24.	414.0	19.8	22 MAR 0945	232	2.	400.1	19.1
20 MAR 0800	33	12.	407.9	19.5	21 MAR 0900	133	23.	413.5	19.8	22 MAR 1000	233	2.	400.0	19.1
20 MAR 0815	34	13.	408.4	19.5	21 MAR 0915	134	22.	413.0	19.8	22 MAR 1015	234	2.	400.0	19.1
20 MAR 0830	35	14.	408.9	19.6	21 MAR 0930	135	21.	412.6	19.7	22 MAR 1030	235	1.	400.0	19.1
20 MAR 0845	36	15.	409.4	19.6	21 MAR 0945	136	20.	412.1	19.7	22 MAR 1045	236	1.	399.9	19.1
20 MAR 0900	37	16.	410.0	19.6	21 MAR 1000	137	19.	411.7	19.7	22 MAR 1100	237	1.	399.9	19.1
20 MAR 0915	38	17.	410.6	19.6	21 MAR 1015	138	18.	411.4	19.7	22 MAR 1115	238	1.	399.9	19.1
20 MAR 0930	39	18.	411.3	19.7	21 MAR 1030	139	18.	411.0	19.7	22 MAR 1130	239	1.	399.8	19.1
20 MAR 0945	40	20.	412.0	19.7	21 MAR 1045	140	17.	410.6	19.6	22 MAR 1145	240	1.	399.8	19.1
20 MAR 1000	41	21.	412.8	19.8	21 MAR 1100	141	16.	410.3	19.6	22 MAR 1200	241	1.	399.8	19.1
20 MAR 1015	42	23.	413.6	19.8	21 MAR 1115	142	16.	409.9	19.6	22 MAR 1215	242	1.	399.8	19.1
20 MAR 1030	43	25.	414.4	19.8	21 MAR 1130	143	15.	409.6	19.6	22 MAR 1230	243	1.	399.7	19.1
20 MAR 1045	44	27.	415.4	19.9	21 MAR 1145	144	15.	409.3	19.6	22 MAR 1245	244	1.	399.7	19.1
20 MAR 1100	45	30.	416.6	19.9	21 MAR 1200	145	14.	409.0	19.6	22 MAR 1300	245	1.	399.7	19.1
20 MAR 1115	46	33.	418.1	20.0	21 MAR 1215	146	14.	408.7	19.6	22 MAR 1315	246	1.	399.7	19.1
20 MAR 1130	47	38.	420.0	20.1	21 MAR 1230	147	13.	408.5	19.5	22 MAR 1330	247	1.	399.6	19.1
20 MAR 1145	48	52.	425.3	20.4	21 MAR 1245	148	13.	408.2	19.5	22 MAR 1345	248	1.	399.6	19.1
20 MAR 1200	49	63.	438.6	20.5	21 MAR 1300	149	12.	407.9	19.5	22 MAR 1400	249	1.	399.6	19.1
20 MAR 1215	50	67.	455.6	20.6	21 MAR 1315	150	12.	407.7	19.5	22 MAR 1415	250	1.	399.6	19.1
20 MAR 1230	51	71.	467.9	20.7	21 MAR 1330	151	11.	407.5	19.5	22 MAR 1430	251	1.	399.5	19.1
20 MAR 1245	52	73.	474.5	20.7	21 MAR 1345	152	11.	407.2	19.5	22 MAR 1445	252	1.	399.5	19.1
20 MAR 1300	53	74.	478.0	20.7	21 MAR 1400	153	11.	407.0	19.5	22 MAR 1500	253	1.	399.5	19.1
20 MAR 1315	54	74.	479.9	20.7	21 MAR 1415	154	10.	406.8	19.5	22 MAR 1515	254	1.	399.5	19.1
20 MAR 1330	55	74.	480.9	20.7	21 MAR 1430	155	10.	406.6	19.5	22 MAR 1530	255	1.	399.5	19.1
20 MAR 1345	56	75.	481.4	20.7	21 MAR 1445	156	10.	406.4	19.4	22 MAR 1545	256	1.	399.4	19.1
20 MAR 1400	57	75.	481.6	20.7	21 MAR 1500	157	9.	406.2	19.4	22 MAR 1600	257	1.	399.4	19.1
20 MAR 1415	58	75.	481.5	20.7	21 MAR 1515	158	9.	406.0	19.4	22 MAR 1615	258	1.	399.4	19.1
20 MAR 1430	59	74.	481.3	20.7	21 MAR 1530	159	9.	405.8	19.4	22 MAR 1630	259	1.	399.4	19.1
20 MAR 1445	60	74.	480.9	20.7	21 MAR 1545	160	8.	405.6	19.4	22 MAR 1645	260	1.	399.3	19.1
20 MAR 1500	61	74.	480.5	20.7	21 MAR 1600	161	8.	405.5	19.4	22 MAR 1700	261	1.	399.3	19.1
20 MAR 1515	62	74.	480.0	20.7	21 MAR 1615	162	8.	405.3	19.4	22 MAR 1715	262	1.	399.3	19.1
20 MAR 1530	63	74.	479.5	20.7	21 MAR 1630	163	8.	405.1	19.4	22 MAR 1730	263	1.	399.3	19.1
20 MAR 1545	64	74.	478.9	20.7	21 MAR 1645	164	7.	405.0	19.4	22 MAR 1745	264	1.	399.3	19.1
20 MAR 1600	65	74.	478.4	20.7	21 MAR 1700	165	7.	404.8	19.4	22 MAR 1800	265	1.	399.3	19.1
20 MAR 1615	66	74.	477.9	20.7	21 MAR 1715	166	7.	404.7	19.4	22 MAR 1815	266	1.	399.2	19.1
20 MAR 1630	67	73.	477.2	20.7	21 MAR 1730	167	7.	404.6	19.4	22 MAR 1830	267	1.	399.2	19.1
20 MAR 1645	68	73.	476.3	20.7	21 MAR 1745	168	7.	404.4	19.3	22 MAR 1845	268	1.	399.2	19.1
20 MAR 1700	69	73.	475.5	20.7	21 MAR 1800	169	6.	404.3	19.3	22 MAR 1900	269	1.	399.2	19.1
20 MAR 1715	70	73.	474.6	20.7	21 MAR 1815	170	6.	404.1	19.3	22 MAR 1915	270	1.	399.2	19.1
20 MAR 1730	71	72.	473.8	20.7	21 MAR 1830	171	6.	404.0	19.3	22 MAR 1930	271	1.	399.1	19.1
20 MAR 1745	72	72.	472.9	20.7	21 MAR 1845	172	6.	403.9	19.3	22 MAR 1945	272	1.	399.1	19.1
20 MAR 1800	73	72.	472.0	20.7	21 MAR 1900	173	6.	403.8	19.3	22 MAR 2000	273	1.	399.1	19.1
20 MAR 1815	74	72.	471.2	20.7	21 MAR 1915	174	6.	403.7	19.3	22 MAR 2015	274	1.	399.1	19.1
20 MAR 1830	75	71.	470.3	20.7	21 MAR 1930	175	5.	403.6	19.3	22 MAR 2030	275	1.	399.1	19.1
20 MAR 1845	76	71.	469.4	20.7	21 MAR 1945	176	5.	403.4	19.3	22 MAR 2045	276	1.	399.1	19.1
20 MAR 1900	77	71.	468.6	20.7	21 MAR 2000	177	5.	403.3	19.3	22 MAR 2100	277	1.	399.0	19.1
20 MAR 1915	78	71.	467.7	20.7	21 MAR 2015	178	5.	403.2	19.3	22 MAR 2115	278	1.	399.0	19.1
20 MAR 1930	79	70.	466.9	20.7	21 MAR 2030	179	5.	403.1	19.3	22 MAR 2130	279	1.	399.0	19.1
20 MAR 1945	80	70.	466.0	20.7	21 MAR 2045	180	5.	403.0	19.3	22 MAR 2145	280	1.	399.0	19.1
20 MAR 2000	81	70.	465.2	20.7	21 MAR 2100	181	5.	402.9	19.3	22 MAR 2200	281	1.	399.0	19.1
20 MAR 2015	82	70.	464.3	20.7	21 MAR 2115	182	5.	402.8	19.3	22 MAR 2215	282	1.	399.0	19.1
20 MAR 2030	83	69.	463.4	20.7	21 MAR 2130	183	4.	402.7	19.3	22 MAR 2230	283	1.	399.0	19.1
20 MAR 2045	84	69.	462.4	20.7	21 MAR 2145	184	4.	402.7	19.3	22 MAR 2245	284	1.	398.9	19.1
20 MAR 2100	85	69.	461.4	20.6	21 MAR 2200	185	4.	402.6	19.3	22 MAR 2300	285	1.	398.9	19.1
20 MAR 2115	86	69.	460.4	20.6	21 MAR 2215	186	4.	402.5	19.2	22 MAR 2315	286	1.	398.9	19.1
20 MAR 2130	87	68.	459.4	20.6	21 MAR 2230	187	4.	402.4	19.2	22 MAR 2330	287	1.	398.9	19.1
20 MAR 2145	88	68.	458.4	20.6	21 MAR 2245	188	4.	402.3	19.2	22 MAR 2345	288	1.	398.9	19.1

20 MAR 2200	89	68.	457.4	20.6 *	21 MAR 2300	189	4.	402.2	19.2 *	23 MAR 0000	289	1.	398.9	19.1
20 MAR 2215	90	68.	456.4	20.6 *	21 MAR 2315	190	4.	402.2	19.2 *	23 MAR 0015	290	1.	398.9	19.1
20 MAR 2230	91	67.	455.4	20.6 *	21 MAR 2330	191	4.	402.1	19.2 *	23 MAR 0030	291	1.	398.8	19.1
MAR 2245	92	67.	454.4	20.6 *	21 MAR 2345	192	4.	402.0	19.2 *	23 MAR 0045	292	1.	398.8	19.1
MAR 2300	93	67.	453.5	20.6 *	22 MAR 0000	193	3.	401.9	19.2 *	23 MAR 0100	293	1.	398.8	19.1
MAR 2315	94	66.	452.5	20.6 *	22 MAR 0015	194	3.	401.9	19.2 *	23 MAR 0115	294	1.	398.8	19.1
MAR 2330	95	66.	451.6	20.6 *	22 MAR 0030	195	3.	401.8	19.2 *	23 MAR 0130	295	1.	398.8	19.1
20 MAR 2345	96	66.	450.6	20.6 *	22 MAR 0045	196	3.	401.7	19.2 *	23 MAR 0145	296	1.	398.8	19.1
21 MAR 0000	97	66.	449.7	20.6 *	22 MAR 0100	197	3.	401.7	19.2 *	23 MAR 0200	297	1.	398.8	19.1
MAR 0015	98	65.	448.6	20.6 *	22 MAR 0115	198	3.	401.6	19.2 *	23 MAR 0215	298	1.	398.8	19.1
MAR 0030	99	65.	447.5	20.6 *	22 MAR 0130	199	3.	401.5	19.2 *	23 MAR 0230	299	1.	398.7	19.1
MAR 0045	100	65.	446.2	20.6 *	22 MAR 0145	200	3.	401.5	19.2 *	23 MAR 0245	300	1.	398.7	19.1

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	74.75-HR
(CFS)	(HR)					
		(CFS)				
75.	14.00		73.	58.	22.	21.
		(INCHES)	1.896	5.965	6.908	6.911
		(AC-FT)	36.	115.	133.	133.

K STORAGE	TIME	MAXIMUM AVERAGE STORAGE			
		6-HR	24-HR	72-HR	74.75-HR
(AC-FT)	(HR)				
482.	14.00	477.	447.	417.	417.

PEAK STAGE	TIME	MAXIMUM AVERAGE STAGE			
		6-HR	24-HR	72-HR	74.75-HR
(FEET)	(HR)				
20.74	14.00	20.72	20.45	19.64	19.62

CUMULATIVE AREA = .36 SQ MI

STATION STORG

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                      (I) INFLOW,   (O) OUTFLOW
         0.       200.      400.      600.      800.     1000.        0.        0.        0.        0.        0.        0.        0.
                                                                                (S) STORAGE
                    0.        0.        0.        0.        0.       360.      400.      440.      480.      520.        0.        0.
         0.
DAHRMN PER
00000    1I---------.---------.---------.---------.---------.---------.--------S.---------.---------.---------.---------.---------.
00015    2I         .         .         .         .         .         .        S.         .         .         .         .         .
00030    3I         .         .         .         .         .         .        S.         .         .         .         .         .
200045   4I         .         .         .         .         .         .        S.         .         .         .         .         .
200100   5I         .         .         .         .         .         .        S.         .         .         .         .         .
200115   6I         .         .         .         .         .         .        S.         .         .         .         .         .
00130    7OI        .         .         .         .         .         .         S         .         .         .         .         .
00145    8OI        .         .         .         .         .         .         S         .         .         .         .         .
00200    9OI        .         .         .         .         .         .         S         .         .         .         .         .
00215   10OI        .         .         .         .         .         .         S         .         .         .         .         .
200230  11OI. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . . . . .
200245  12OI        .         .         .         .         .         .         S         .         .         .         .         .
00300   13OI        .         .         .         .         .         .         S         .         .         .         .         .
00315   14OI        .         .         .         .         .         .         S         .         .         .         .         .
00330   15OI        .         .         .         .         .         .         S         .         .         .         .         .
00345   16OI        .         .         .         .         .         .         S         .         .         .         .         .
200400  17OI        .         .         .         .         .         .         S         .         .         .         .         .
200415  18OI        .         .         .         .         .         .         S         .         .         .         .         .
00430   19OI        .         .         .         .         .         .         .S        .         .         .         .         .
00445   20OI        .         .         .         .         .         .         .S        .         .         .         .         .
00500   21OI. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . . . . . . . . . . . . .
00515   22OI        .         .         .         .         .         .         .S        .         .         .         .         .
200530  23OI        .         .         .         .         .         .         .S        .         .         .         .         .
200545  24OI        .         .         .         .         .         .         .S        .         .         .         .         .
200600  25OI        .         .         .         .         .         .         .S        .         .         .         .         .
00615   26OI        .         .         .         .         .         .         .S        .         .         .         .         .
00630   27OI        .         .         .         .         .         .         .S        .         .         .         .         .
00645   28OI        .         .         .         .         .         .         .S        .         .         .         .         .
200700  29OI        .         .         .         .         .         .         . S       .         .         .         .         .
200715  30O I       .         .         .         .         .         .         . S       .         .         .         .         .
200730   31.OI . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . . . .
00745    32.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200800   33.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200815   34.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200830   35.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200845   36.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200900   37.OI      .         .         .         .         .         .         . S       .         .         .         .         .
200915   38.OI      .         .         .         .         .         .         .  S      .         .         .         .         .
200930   39.O I     .         .         .         .         .         .         .  S      .         .         .         .         .
200945   40.O I     .         .         .         .         .         .         .  S      .         .         .         .         .
201000   41.O.I. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . . . .
201015   42.O I     .         .         .         .         .         .         .   S     .         .         .         .         .
201030   43.O I     .         .         .         .         .         .         .   S     .         .         .         .         .
201045   44.O  I    .         .         .         .         .         .         .   S     .         .         .         .         .
201100   45.O  I    .         .         .         .         .         .         .    S    .         .         .         .         .
201115   46. O  I   .         .         .         .         .         .         .    S    .         .         .         .         .
201130   47. O    I .         .         .         .         .         .         .     S   .         .         .         .         .
201145   48.  O     .         .  I      .         .         .         .         .         S         .         .         .         .
201200   49.  O     .         .         .         .      I  .         .         .         .   S     .         .         .         .
201215   50.  O     .         .         .         . I       .         .         .         .       S .         .         .         .
201230   51. . O . . . . . . . . . . . . . I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . .
201245   52.   O    .    I    .         .         .         .         .         .         .         S         .         .         .
201300   53.   O    I         .         .         .         .         .         .         .         S         .         .         .
201315   54.   O  I .         .         .         .         .         .         .         .         S         .         .         .
201330   55.   OI   .         .         .         .         .         .         .         .         S         .         .         .
201345   56.    I   .         .         .         .         .         .         .         .         S         .         .         .
201400   57.    I   .         .         .         .         .         .         .         .         S         .         .         .
201415   58.   IO   .         .         .         .         .         .         .         .         S         .         .         .
201430   59.   IO   .         .         .         .         .         .         .         .         S         .         .         .
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445 60.  IO       S
201500 61. .IO    S
201515 62.  IO    S
201530 63. I O    S
545 64. I O       S
600 65. I O       S.
615 66. I O       S.
201630 67. I O    S.
201645 68. I O    S.
201700 69. I O    S.
715 70. I O       S
1730 71.I. O      S
1745 72.I  O      S
201800 73. I O    S
201815 74. I O    S
201830 75.I  O    S
201845 76.I  O    S
1900 77.I  O      S
1915 78.I  O      S
1930 79. I O      S
201945 80. I O    S
202000 81.I.O.    S
202015 82.I O     S
2030 83.I O       S
2045 84.I O       S
2100 85.I O       S
202115 86.I O     S
202130 87.I O     S
202145 88.I O     S
2200 89.I O       S
2215 90.I O       S
2230 91.I.O.      S
202245 92.I O     S
202300 93.I O     S
202315 94.I O     S
202330 95.I O     S
2345 .96.I O      S
0000 97.I O       S
0015 98.I O       S
210030 99I  O     S
210045 100I  O    .S.
210100 101I .O.   S
0115 102I  O      .S
0130 103I  O      S
0145 104I  O      S
210200 105I  O    S
210215 106I  O    S.
210230 107I  O    S.
210245 108I  O    S.
10300 109I  O     S
10315 110I  O     S
10330 111I .O.    S
210345 112I  O    S
210400 113I  O    S
210415 114I  O    S
10430 115I  O     S
10445 116I  O     S
10500 117I  O     S
210515 118I O     S
210530 119I O     S
210545 120I O     .S.
10600 121I O      S
10615 122I O      S
10630 123I O      S
10645 124I O      S
210700 125I O     S
210715 126I O     S
210730 127I O     S
10745 128IO       S
10800 129IO       S
10815 130IO       S
210830 131IO.     S
210845 132IO      S
210900 133IO      S
210915 134IO      S
210930 135IO      S
210945 136IO      S
211000 137IO      S
211015 138IO      S
211030 139IO      S
211045 140IO      .S.
211100 141IO.     .S
211115 142IO      .S
211130 143IO      .S
211145 144IO      .S
211200 145IO      .S
211215 146IO      .S
211230 147IO      .S
211245 148IO      .S
211300 149IO      .S
211315 150IO      .S
211330 151IO.     .S
211345 152IO      .S
211400 153IO      .S
211415 154IO      .S
211430 155I       .S
211445 156I       .S
211500 157I       .S
211515 158I       .S
211530 159I       .S
211545 160I       .S
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1600 161I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . . . . . . . . . .
211615 162I        .        .        .        .        .        .        .S        .        .        .        .        .
211630 163I        .        .        .        .        .        .        .S        .        .        .        .        .
1645 164I          .        .        .        .        .        .        .S        .        .        .        .        .
1700 165I          .        .        .        .        .        .        .S        .        .        .        .        .
1715 166I          .        .        .        .        .        .        .S        .        .        .        .        .
1730 167I          .        .        .        .        .        .        .S        .        .        .        .        .
211745 168I        .        .        .        .        .        .        .S        .        .        .        .        .
211800 169I        .        .        .        .        .        .        .S        .        .        .        .        .
211815 170I        .        .        .        .        .        .        .S        .        .        .        .        .
1830 171I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . . . . . . . . . .
1845 172I          .        .        .        .        .        .        .S        .        .        .        .        .
1900 173I          .        .        .        .        .        .        .S        .        .        .        .        .
211915 174I        .        .        .        .        .        .        .S        .        .        .        .        .
211930 175I        .        .        .        .        .        .        .S        .        .        .        .        .
211945 176I        .        .        .        .        .        .        .S        .        .        .        .        .
2000 177I          .        .        .        .        .        .        .S        .        .        .        .        .
2015 178I          .        .        .        .        .        .        .S        .        .        .        .        .
2030 179I          .        .        .        .        .        .        .S        .        .        .        .        .
2045 180I          .        .        .        .        .        .        .S        .        .        .        .        .
212100 181I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . . . . . . . . . .
212115 182I        .        .        .        .        .        .        .S        .        .        .        .        .
2130 183I          .        .        .        .        .        .        .S        .        .        .        .        .
2145 184I          .        .        .        .        .        .        .S        .        .        .        .        .
2200 185I          .        .        .        .        .        .        .S        .        .        .        .        .
2215 186I          .        .        .        .        .        .        .S        .        .        .        .        .
212230 187I        .        .        .        .        .        .        .S        .        .        .        .        .
212245 188I        .        .        .        .        .        .        .S        .        .        .        .        .
12300 189I         .        .        .        .        .        .        .S        .        .        .        .        .
2315 190I          .        .        .        .        .        .        .S        .        .        .        .        .
2330 191I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S. . . . . . . . . . . . . . . . . . . . . .
2345 192I          .        .        .        .        .        .        .S        .        .        .        .        .
220000 193I        .        .        .        .        .        .        S         .        .        .        .        .
220015 194I        .        .        .        .        .        .        S         .        .        .        .        .
220030 195I        .        .        .        .        .        .        S         .        .        .        .        .
20045 196I         .        .        .        .        .        .        S         .        .        .        .        .
20100 197I         .        .        .        .        .        .        S         .        .        .        .        .
20115 198I         .        .        .        .        .        .        S         .        .        .        .        .
20130 199I         .        .        .        .        .        .        S         .        .        .        .        .
220145 200I        .        .        .        .        .        .        S         .        .        .        .        .
220200 201I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . .
220215 202I        .        .        .        .        .        .        S         .        .        .        .        .
20230 203I         .        .        .        .        .        .        S         .        .        .        .        .
20245 204I         .        .        .        .        .        .        S         .        .        .        .        .
20300 205I         .        .        .        .        .        .        S         .        .        .        .        .
220315 206I        .        .        .        .        .        .        S         .        .        .        .        .
220330 207I        .        .        .        .        .        .        S         .        .        .        .        .
220345 208I        .        .        .        .        .        .        S         .        .        .        .        .
20400 209I         .        .        .        .        .        .        S         .        .        .        .        .
20415 210I         .        .        .        .        .        .        S         .        .        .        .        .
20430 211I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . .
20445 212I         .        .        .        .        .        .        S         .        .        .        .        .
220500 213I        .        .        .        .        .        .        S         .        .        .        .        .
220515 214I        .        .        .        .        .        .        S         .        .        .        .        .
20530 215I         .        .        .        .        .        .        S         .        .        .        .        .
20545 216I         .        .        .        .        .        .        S         .        .        .        .        .
20600 217I         .        .        .        .        .        .        S         .        .        .        .        .
20615 218I         .        .        .        .        .        .        S         .        .        .        .        .
220630 219I        .        .        .        .        .        .        S         .        .        .        .        .
220645 220I        .        .        .        .        .        .        S         .        .        .        .        .
220700 221I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . .
20715 222I         .        .        .        .        .        .        S         .        .        .        .        .
20730 223I         .        .        .        .        .        .        S         .        .        .        .        .
20745 224I         .        .        .        .        .        .        S         .        .        .        .        .
220800 225I        .        .        .        .        .        .        S         .        .        .        .        .
220815 226I        .        .        .        .        .        .        S         .        .        .        .        .
220830 227I        .        .        .        .        .        .        S         .        .        .        .        .
20845 228I         .        .        .        .        .        .        S         .        .        .        .        .
20900 229I         .        .        .        .        .        .        S         .        .        .        .        .
20915 230I         .        .        .        .        .        .        S         .        .        .        .        .
20930 231I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . .
220945 232I        .        .        .        .        .        .        S         .        .        .        .        .
221000 233I        .        .        .        .        .        .        S         .        .        .        .        .
221015 234I        .        .        .        .        .        .        S         .        .        .        .        .
221030 235I        .        .        .        .        .        .        S         .        .        .        .        .
221045 236I        .        .        .        .        .        .        S         .        .        .        .        .
221100 237I        .        .        .        .        .        .        S         .        .        .        .        .
221115 238I        .        .        .        .        .        .        S         .        .        .        .        .
221130 239I        .        .        .        .        .        .        S         .        .        .        .        .
221145 240I        .        .        .        .        .        .        S         .        .        .        .        .
221200 241I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .S . . . . . . . . . . . . . . . . . . . . . .
221215 242I        .        .        .        .        .        .        S         .        .        .        .        .
221230 243I        .        .        .        .        .        .        S         .        .        .        .        .
221245 244I        .        .        .        .        .        .        S         .        .        .        .        .
221300 245I        .        .        .        .        .        .        S         .        .        .        .        .
221315 246I        .        .        .        .        .        .        S         .        .        .        .        .
221330 247I        .        .        .        .        .        .        S         .        .        .        .        .
221345 248I        .        .        .        .        .        .        S         .        .        .        .        .
221400 249I        .        .        .        .        .        .        S         .        .        .        .        .
221415 250I        .        .        .        .        .        .        S         .        .        .        .        .
221430 251I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . .
221445 252I        .        .        .        .        .        .        S         .        .        .        .        .
221500 253I        .        .        .        .        .        .        S         .        .        .        .        .
221515 254I        .        .        .        .        .        .        S         .        .        .        .        .
221530 255I        .        .        .        .        .        .        S         .        .        .        .        .
221545 256I        .        .        .        .        .        .        S         .        .        .        .        .
221600 257I        .        .        .        .        .        .        S         .        .        .        .        .
221615 258I        .        .        .        .        .        .        S         .        .        .        .        .
221630 259I        .        .        .        .        .        .        S         .        .        .        .        .
221645 260I        .        .        .        .        .        .        S         .        .        .        .        .
221700 261I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . .
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                                                                S
21715 262I         .        .        .        .        .        .        S        .        .        .        .        .
21730 263I         .        .        .        .        .        .        S        .        .        .        .        .
21745 264I         .        .        .        .        .        .        S        .        .        .        .        .
   00 265I         .        .        .        .        .        .        S        .        .        .        .        .
   I5 266I         .        .        .        .        .        .        S        .        .        .        .        .
   30 267I         .        .        .        .        .        .        S        .        .        .        .        .
21845 268I         .        .        .        .        .        .        S        .        .        .        .        .
21900 269I         .        .        .        .        .        .        S        .        .        .        .        .
21915 270I         .        .        .        .        .        .        S        .        .        .        .        .
  930 271I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . . . .
  945 272I         .        .        .        .        .        .        S        .        .        .        .        .
  000 273I         .        .        .        .        .        .        S        .        .        .        .        .
  0I5 274I         .        .        .        .        .        .        S        .        .        .        .        .
222030 275I        .        .        .        .        .        .        S        .        .        .        .        .
222045 276I        .        .        .        .        .        .        S        .        .        .        .        .
   100 277I        .        .        .        .        .        .        S        .        .        .        .        .
   II5 278I        .        .        .        .        .        .        S        .        .        .        .        .
   I30 279I        .        .        .        .        .        .        S        .        .        .        .        .
   I45 280I        .        .        .        .        .        .        S        .        .        .        .        .
222200 281I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . . .
222215 282I        .        .        .        .        .        .        S        .        .        .        .        .
222230 283I        .        .        .        .        .        .        S        .        .        .        .        .
   245 284I        .        .        .        .        .        .        S        .        .        .        .        .
   300 285I        .        .        .        .        .        .        S        .        .        .        .        .
   315 286I        .        .        .        .        .        .        S        .        .        .        .        .
222330 287I        .        .        .        .        .        .        S        .        .        .        .        .
222345 288I        .        .        .        .        .        .        S        .        .        .        .        .
230000 289I        .        .        .        .        .        .        S        .        .        .        .        .
   00I5 290I       .        .        .        .        .        .        S        .        .        .        .        .
   0030 291I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . S . . . . . . . . . . . . . . . . . . . . . . .
   0045 292I       .        .        .        .        .        .        S        .        .        .        .        .
   0100 293I       .        .        .        .        .        .        S        .        .        .        .        .
230II5 294I        .        .        .        .        .        .        S        .        .        .        .        .
230I30 295I        .        .        .        .        .        .        S        .        .        .        .        .
230I45 296I        .        .        .        .        .        .        S        .        .        .        .        .
   0200 297I       .        .        .        .        .        .        S        .        .        .        .        .
   0215 298I       .        .        .        .        .        .        S        .        .        .        .        .
   0230 299I       .        .        .        .        .        .        S        .        .        .        .        .
230245 300I---------.---------.---------.---------.---------.---------.---------S---------.---------.---------.---------.---------.
1
1
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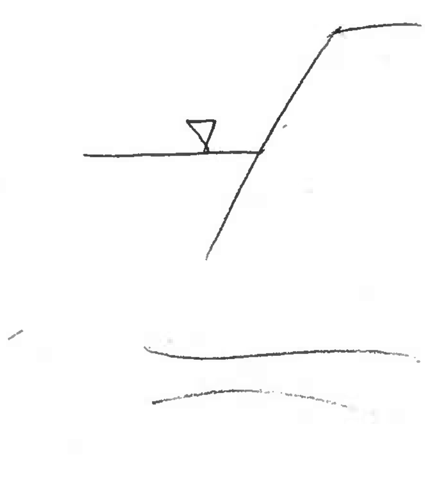
RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
RYDROGRAPH AT	CP A	933.	I2.00	I93.	68.	23.	.36		
ROUTED TO	STORG	75.	I4.00	73.	58.	22.	.36	20.74	I4.00

+

*** NORMAL END OF HEC-1 ***



Culvert Computations

SPILLWAY #3

Culvert Calculator Report
Worksheet-1

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	3.0 ft	Headwater Depth/ Height	0.69
Computed Headwater Elevation	12.9 ft	Discharge	51.00 cfs
Inlet Control HW Elev	12.6 ft	Tailwater Elevation	0.7 ft
Outlet Control HW Elev	12.9 ft	Control Type	Outlet Control

Grades

Upstream Invert	10.8 ft	Downstream Invert	6.9 ft
Length	102.0 ft	Constructed Slope	0.038549 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	0.7 ft
Slope Type	Steep	Normal Depth	0.7 ft
Flow Regime	Supercritical	Critical Depth	1.3 ft
Velocity Downstream	12.6 ft/s	Critical Slope	0.004073 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	3.0 ft
Section Size	36 inch	Rise	3.0 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev	12.9 ft	Upstream Velocity Head	0.5 ft
Ke	0.50	Entrance Loss	0.3 ft

Inlet Control Properties

Inlet Control HW Elev	12.6 ft	Flow Control	Unsubmerged
Inlet Type	Square edge w/headwall	Area Full	21 ft^2
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

S.O. No. ____

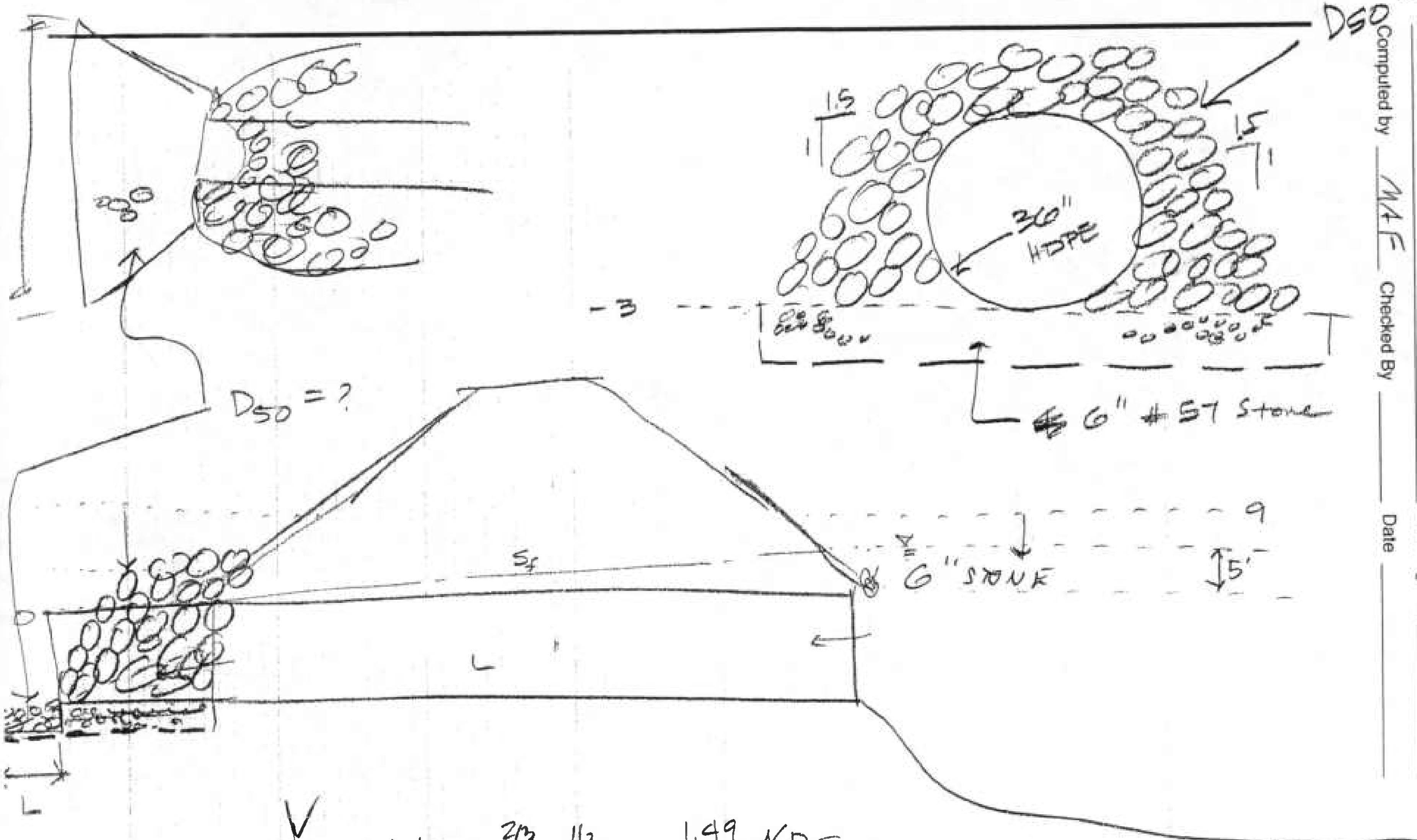
Subject: HART-MILLER ISLAND

BAY CULVERT

Sheet No. ____ of ____

Drawing No. ____

Computed by MAF Checked By ____ Date ____



$$\overset{V}{\cancel{Q}} = \frac{1.49}{n} A R^{2/3} S_f^{1/2} = \frac{1.49}{0.011} \cancel{A} R S_f$$

Baker

S.O. No.

Subject: HART MILLER ISLAND

BAY CULVERT CALC'S. Sheet No. of

Drawing No.

Computed by MAF Checked By Date

Baker

END = 0

> 90°

M-1 = 102

M-2 = 420

M-3 = 675

M-4 = 945 > 90°

END = 1157

36" HDPE

$A = 7.065 \ ft^2$

$R = D/4 = 3/4 = .75$

TOTAL LENGTH = 1157'

$$S_f = \frac{5}{1157} = 0.0043$$

$$Q = \frac{1.49}{n} A R^{2/3} S_f^{1/2} = \frac{1.49}{0.011} A R^{2/3} S_f^{1/2}$$

$$Q = \frac{1.49}{0.011} (7.065)(0.75)^{2/3} (0.0043)^{1/2}$$

$$Q = 135.45 (7.065)(0.75)^{2/3} (0.0043)^{1/2}$$

$$Q = 956.99 (0.75)^{2/3} (0.0043)^{1/2}$$

$$Q = 62.75 (0.75)^{2/3}$$

$$Q = 51.77 \ cfs$$

$Q = VA$ $\quad V = Q/A = \frac{51.77}{7.065} = 7.33 \ ft/sec.$

S.O. No.

Subject: HART MILLER ISLAND

OUTLET PROTECTION

BAY CULVERT

Sheet No. ____ of ____

Drawing No.

Computed by MAF Checked By ____ Date ____

Baker

OUTLET PROTECTION

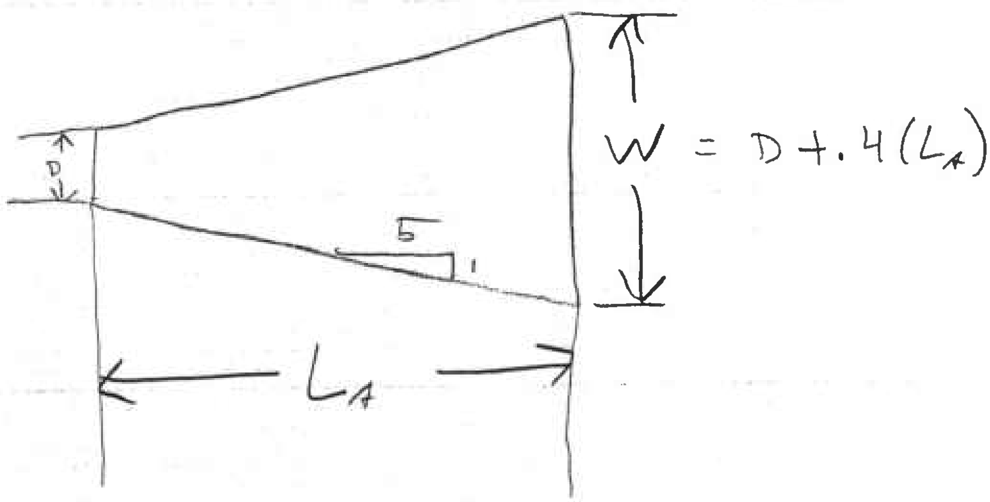
$L_A = 10'$

$d_{50} = 6''$

36" HDPE PIPE

$Q = 51.77$ cfs

$V = 7.33$ ft/sec



$D = 3'$

$L_A = 10'$

$W = 3 + (.4)(10) = 7'$

APPENDIX C

SPILLWAY AND PUMP HOUSE FOUNDATION ANALYSES

PUMP STATION AND STEEL HOIST STRUCTURAL ANALYSES

Spillway #3 Foundation Analysis

S.O. No.

Subject: Hart - Miller Island

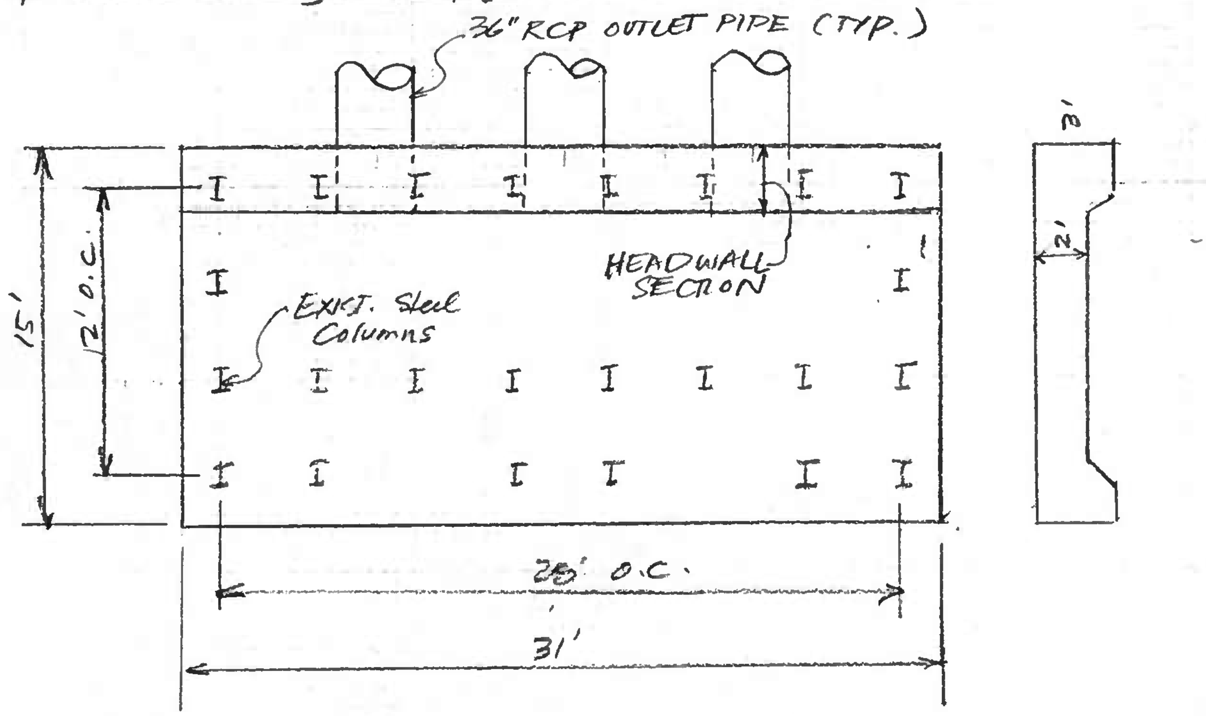
Response to Comment # 28242, Sheet No. 1 of 4

Spillway #3 Foundation Analysis Drawing No.

Computed by EKF Checked By Date 4/17/02

Baker

In the absence of as-built information on existing Spillway No. 3, the foundation slab has been assumed to be of the following configuration:



EXISTING DEAD LOADS:

Wt of Hor Slab	=	139,500 lbs
Wt of Thickened Section	=	27,600
Wt of Headwall	=	28,362
Base Plates	=	2,933
Steel Columns	=	9,600
Hor. Channel Beams	=	2,916
Hor. WF Beams	=	1,456
Pipe Diagonals (2.5"ϕ)	=	349
Steel ladder	=	200 lbs

S.O. No.

Subject: Hart - Miller Island

Response to Comment # 28242 Sheet No. 2 of 4

Spillway # 3 Foundation Analysis Drawing No.

Computed by Checked By Date

Baker

Plastic Grating	=	1,911 lbs
Misc Attachments	=	300
Timber Baffles	=	13,280
Top Railing	=	1,226 lbs

Total Dead Load = 229,553 lbs, say 240,000 lbs

Actual Foundation Bearing Pressure $= \dfrac{240{,}000 \text{ lbs}}{(31)(15)\ ft^2}$

$= 516 \dfrac{lb}{ft^2}$

Wt of 3 new FRP Gates = 1500 lbs (500 lb ea, per manufacturer)

Wt of new Steel ladder = 300 lbs

Actual Foundation Bearing Pressure $= \dfrac{240{,}000 + 1500 + 300}{(31)(15)}$

$= 520 \dfrac{lb}{ft^2} < 1{,}000$ psf, per Geotech report

* Settlement resulting from increased loading will be imperceptible.

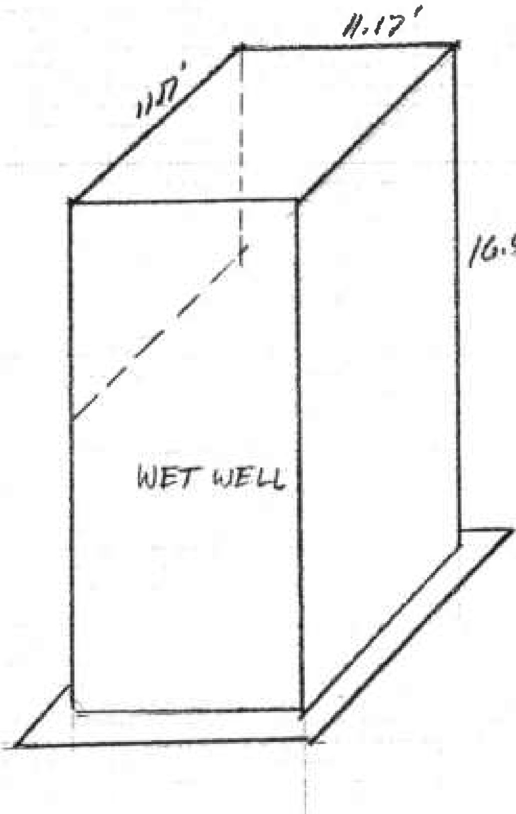
Pump House Foundation Analysis

S.O. No. ______

Subject: Hart - Miller Island
Response to Comment # 28242 Sheet No. 3 of 4
Pump Station Foundation Analysis Drawing No. ______
Computed by EKF Checked By ______ Date 4/17/02

Baker

Note: This analysis is done only for the Wet Wall portion of the Pump Station, which is the more critical portion.



BEARING PRESSURE COMPUTATIONS:

LL: (100 psf)(11.17)(11.17) = 12,477 lbs

DL:

Top Slab = 11.17(11.17)(1.33)(145) = 24,062 lbs
− Grate Opening = 4(6)(1.33)(145) = 4,628
+ Grate = 650
+ Walls (Net) = 107,327 lbs

S.O. No. ____

Subject: Hart-Miller Island
Response to Comment # 28 242 Sheet No. 4 of 4
Pump Station Found. Analysis Drawing No. ____

Computed by EKF Checked By ____ Date 4/17/02

Baker

Bottom Slab = 15.17(15.17)(1.5)(145)	=	50,053 lbs
Pump Equipment		2,600
Hoist Structure		1,812
Misc Items (FRP steps, etc.)		300 lbs

Total DL = 182,175 lbs

Total DL + LL = 194,652 lbs

Actual Foundation Bearing Pressure $= \frac{194,652 \text{ lbs}}{15.17(15.17)}$

= 846 psf < 1,000 psf, per Geotech Report (OK)

During High Water Conditions, when WSEL is @ El. +3.0,
Wt of Water = 8.5(8.5)(9)(62.4) = 40,576 lbs

Total DL = 222,751 lbs

Actual Foundation Bearing Pressure $= \frac{222,751 \text{ lbs}}{15.17(15.17)}$

= 968 psf < 1,000 psf per Geotech Report (OK)

Pump Station Structural Analysis

S.O. No.

Subject: Hart-Miller Island - PUMP STATION STRUC'L DESIGN

Sheet No. 1 of 6

Drawing No.

Computed by EKF Checked By Date 6/7/02

Baker

REFERENCES:

1. Building Code Requirements for Structural Concrete (ACI 318-02)

2. "Rectangular Concrete Tanks", 5th Ed, by Portland Cement Association

3. "Reinforced Concrete Design", 3rd Ed, by Spiegel & Limbrunner

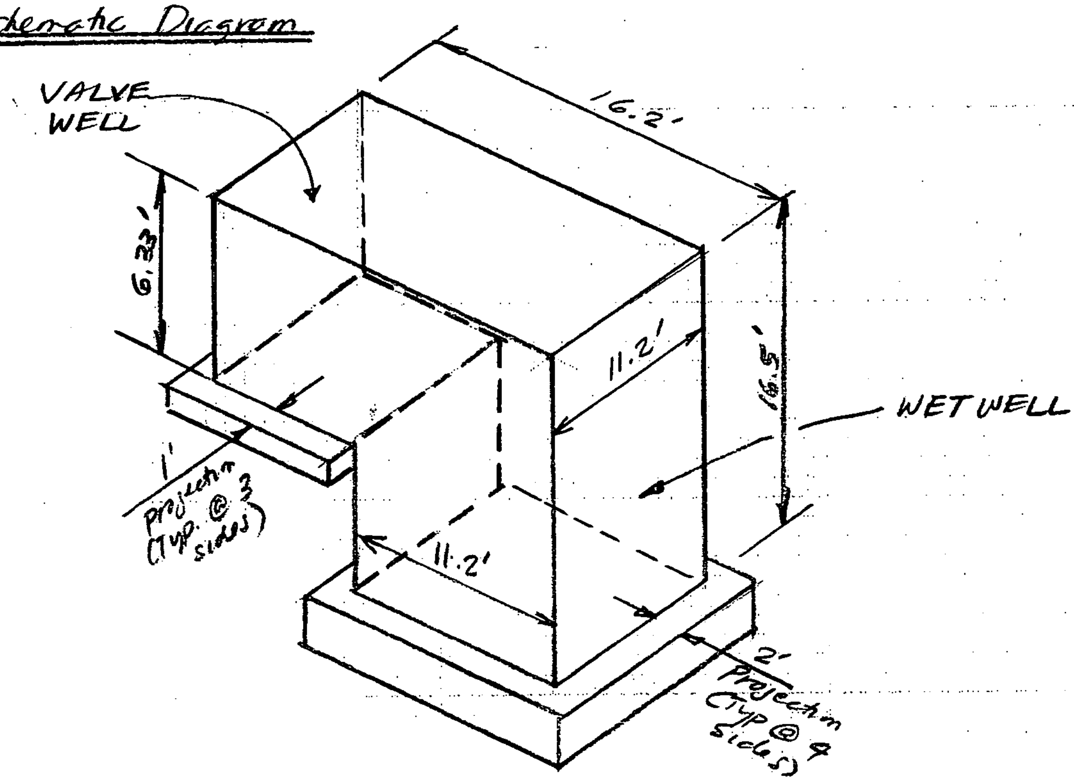
Design Parameters

$f_c' = 4$ ksi $\gamma_w = 62.4$ pcf Roof LL = 100 psf

$f_y = 60$ ksi $\gamma_{soil} = 110$ pcf (assumed)

$k_a = 0.30$

Schematic Diagram



S.O. No. ______

Subject: Hart-Miller Island – PUMP STATION

STRUC'L DESIGN

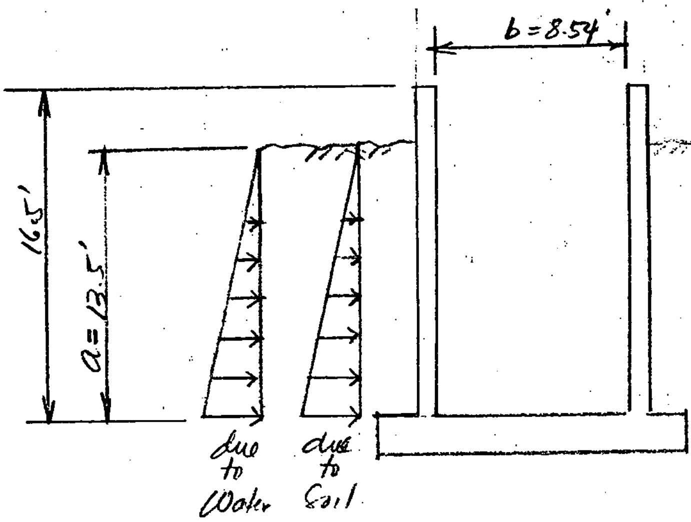
Sheet No. 2 of 6

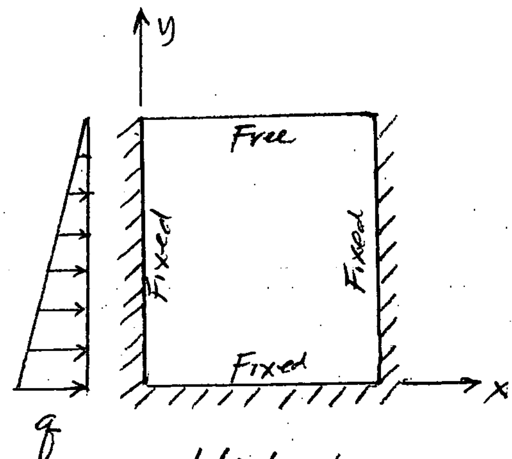
Drawing No. ______

Computed by EKF Checked By ______ Date 6/7/02

Baker

I. DESIGN OF WET WELL





Idealization (Case 3)

Soil Pressure, $q_s = K_a \gamma_s a = 0.30(110)(13.5) = 446$ psf

Water Pressure, $q_w = \gamma_w a = 62.4(13.5) = 842$ psf

Total Pressure, $q = q_s + q_w = 1288$ psf

Check For Shear

$b/a = 8.54/13.5 = 0.63$

$$
\begin{array}{cccc}
 & b/a & C_s & \\
.25 \,\left[\; .12 \left[\begin{array}{c} .75 \\ .63 \\ .50 \end{array}\right. \right. & & \left. \left. \begin{array}{c} .26 \\ x \\ .19 \end{array} \right] .26-x \;\right] .07 &
\end{array}
$$

$$\frac{.26-x}{.07} = \frac{.12}{.25}$$

$X = 0.23$ = Shear Coeff C_s @ midpoint

$V = C_s q a = 0.23(1288)(13.5) = 3999$ lbs

$V_u = 1.7V = 6799$ lbs

$d = 16-3-.5 = 12.5"$

Allow Shear, $V_c = 2\sqrt{f_c'}\,bd = 2\sqrt{4000}\,(12)(12.5)$

$= 18974$ lbs $> V_u = 6799$ lbs

(OK, safe in shear)

S.O. No.

Subject: Hart-Miller Island - PUMP STATION STRUC'L DESIGN

Sheet No. 3 of 6

Drawing No.

Computed by EKF Checked By

Date 6/7/02

Baker

Design For Vertical Bending Moment

$M = M_{coeff} \times q\, a^2$

$= 17(1288)(13.5)^2 = 3,990,546$ ft-#

$= 333$ in-kips

$M_u = 1.7M = 565$ in-kips

Req'd $\bar{K} = \dfrac{M_u}{\phi b d^2} = \dfrac{565}{.9(12)(12.5)^2}$

$= 0.335$

Req'd $\rho = 0.0059 > \rho_{min} = .0033$ (OK)

Req'd $A_s = .0059(12)(12.5) = 0.90$ in^2/ft

Use #9 @ 9" o.c. (A_s sup'd $= 1.33\ in^2$)

b/a	Mcoeff
.75	23
.63	X
.50	11

X = 17 = Mcoeff @ bottom of wall

Note: A check for horizontal bending moment was done, and yielded the same Mcoeff = 17, hence results were identical

∴ USE #9 @ 9" O.C.E.W bars on all 3 walls of the wet well against earth

S.O. No.

Subject: Hart-Miller Island - PUMP STATION STRUC'L DESIGN

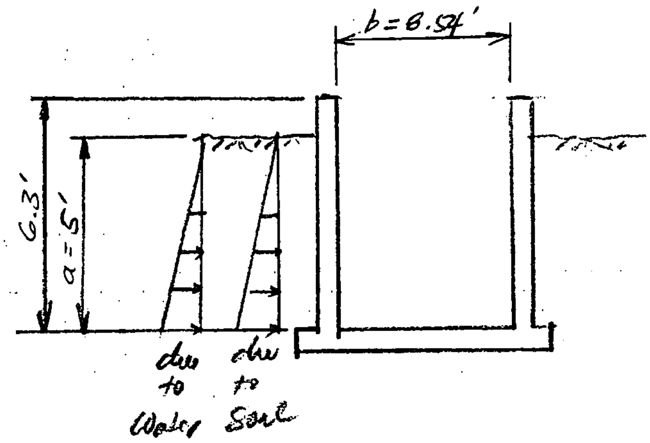
Sheet No. 4 of 6

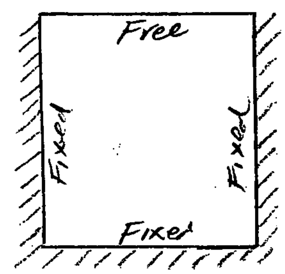
Drawing No.

Computed by EKF Checked By Date 6/7/02

Baker

II. DESIGN OF VALVE WELL





Soil Pressure, $q_s = K_a \gamma_s a = 0.30(110)(5) = 165$ psf

Water Pressure, $q_w = \gamma_w a = 62.4(5) = 312$ psf

Total Pressure, $q = q_s + q_w = 477$ psf

Check for shear

$b/a = \frac{8.54}{5} = 1.7$, use Coefficient for 1.75

$V = C_s q a = 0.43(477)(5) = 1026$ lbs

$V_u = 1.7V = 1743$ lbs

$(d = 12 - 3 - .5 = 8.5")$

$V_c = 2\sqrt{f'_c}\, bd = 2\sqrt{4000}\,(12)(8.5)$

$= 12{,}902$ lbs > 1743 lbs

(OK, safe in shear)

S.O. No.

Subject: Hart-Miller Island - PUMP STATION

STRUC'L DESIGN

Sheet No. 5 of 6

Drawing No.

Computed by EKF Checked By Date 6/7/02

Baker

Design for Vertical Bending Moment

$M = M_{coeff} \times q \times a^2$

$= 73\,(477)(5)^2 = 870525$ ft-#

$= 72.5$ in-k

$M_u = 1.7M = 123.3$ in-k

Req'd $\bar{K} = \dfrac{M_u}{\phi b d^2} = \dfrac{123.3}{.9(12)(8.5)^2} = 0.158$

Req'd $\rho = .0027 < \rho_{min} = .0033$; use $\rho_{min} = .0033$

Req'd $A_s = .0033\,(12)(8.5) = 0.34$ in^2/ft

use #6 @ 9" O.C (As sup'd = .59 in^2)

<u>Note</u>. A check for horizontal bending moment was done and yielded an Mcoeff less than 73, hence a lesser bending moment. However, for consistency, the same reinforcement was used

∴ USE #6 @ 9" O.C. E.W. on all 3 walls of the valve well against earth

S.O. No. ____

Subject: Hart-Miller Island - PUMP STATION STRUC'L DESIGN

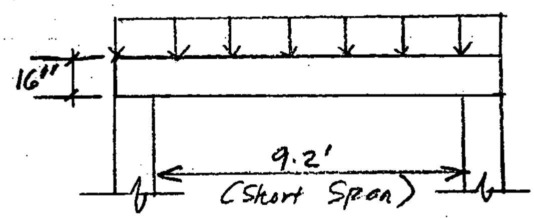
Sheet No. 6 of 6

Drawing No. ____

Computed by EKF Checked By ____ Date 6/7/02

Baker

III. DESIGN OF ROOF SLAB



$$DL = \frac{16(12)}{144}(150) = 200 \text{ lb/ft}$$

$$LL = (100)(1) = 100 \text{ lb/ft}$$

$$\text{Design Load, } w_u = 1.4(200) + 1.7(100) = 450 \text{ lb/ft}$$

$$M_u = \frac{w_u \ell^2}{8} = \frac{450(9.2)^2}{8} = 4{,}761 \text{ ft-\#} = 4.761 \text{ ft-k}$$

$$d = 16 - 2 - .5 = 13.5''$$

$$\text{Req'd } k = \frac{M_u}{\phi b d^2} = \frac{4.761(12)}{.9(12)(13.5)^2} = .0290 \text{ ksi}$$

$$\rightarrow \text{Req'd } \rho = .0010 \text{ ; use } \rho_{min} = .0033$$

$$\text{Req'd } A_s = \rho b d = .0033(12)(13.5) = .5346 \text{ in}^2/\text{ft}$$

$$\underline{\text{Use \# 9 @ 9'' o.c. } (A_{s\,supp'd} = 1.33 \text{ in}^2/\text{ft})}$$

Steel Hoist Structural Analysis

S.O. No. ______

Subject: *Hart-Miller Island — STEEL HOIST DESIGN*

Sheet No. 1 of 6

Drawing No. ______

Computed by EKF Checked By ______ Date 6/7/02

Baker

REFERENCES :

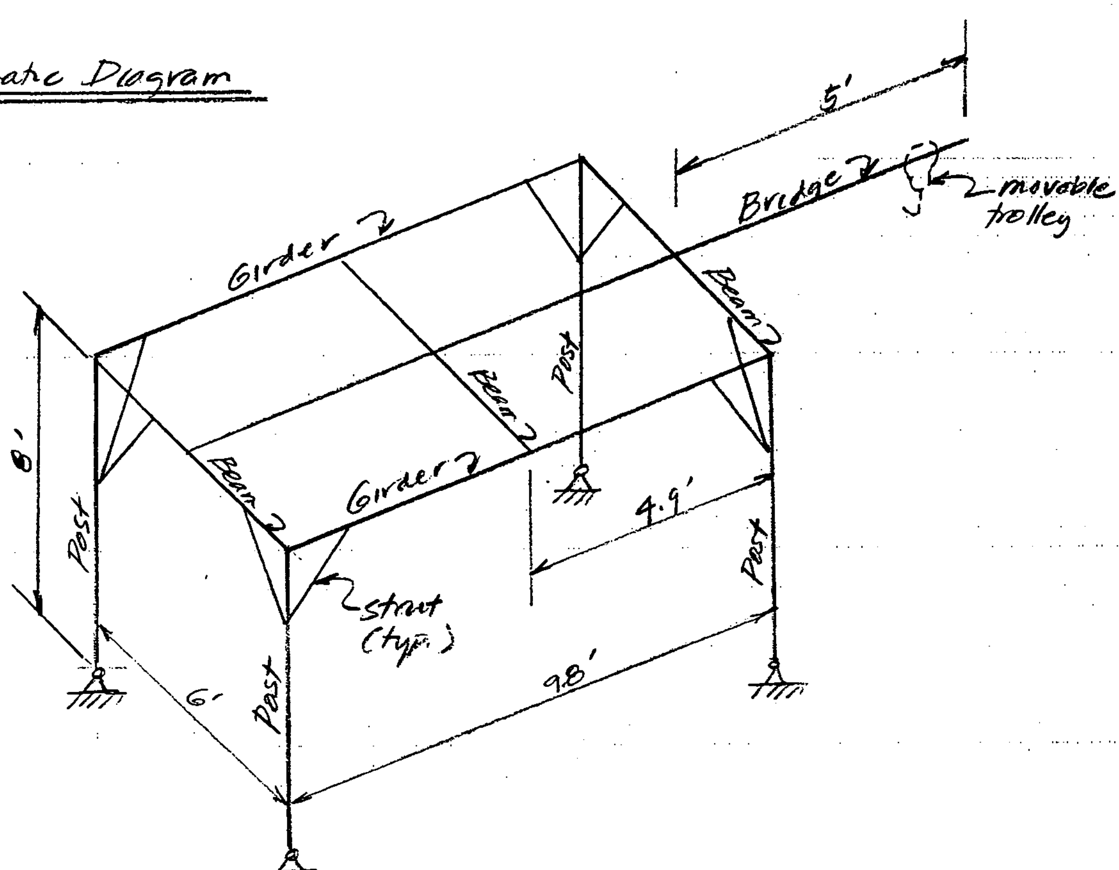
1. A.I.S.C. Manual of Steel Construction, ASD, 9th Ed
2. A.I.S.C. Manual of Steel Construction Vol II, Connections
3. "Applied Structural Steel Design", 2nd Ed, by Spiegel and Limbrunner

Design Parameters

A36 Steel Wt of Pumps to be lifted = 1,800 lbs

Impact, I = 25% Wt of movable trolley = 100 lbs

Schematic Diagram



S.O. No.

Subject: Hart-Miller Island – STEEL HOIST DESIGN

Sheet No. 2 of 6

Drawing No.

Computed by EKF Checked By Date 6/7/02

Baker

Design of Bridge:

pump trolley

Conc. Load $P = 1{,}800 + 100 = 1{,}900$ lbs

$Min.\ d = \frac{L}{20} = \frac{5(12)}{20} = 3''$

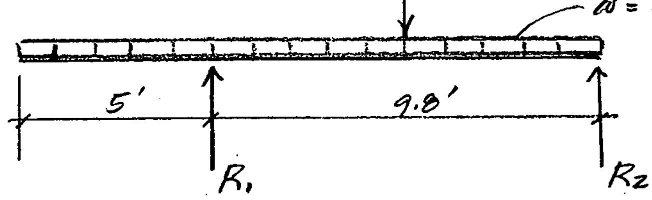
$Min\ t = 5/16''$

Case 1 Load @ Midspan

(25% Impact)

$P = 1.25(1{,}900) = 2{,}375\#$

$w = 20$ plf (assumed)



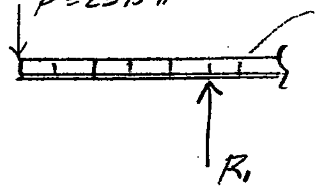
$\Sigma M_{R_1} = 0, \quad R_2 = 1{,}260\ \#$

$\Sigma M_P = 1260\left(\frac{9.8}{2}\right) = 6{,}174$ ft-#

Case 2 Load @ tip of bridge

$P = 2375\#$

$w = 20$ plf



$\Sigma M_{R_1} = 2375(5) + 20(5)\left(\frac{5}{2}\right) = 12{,}125$ ft-# ← Des M

Try S 8 × 23 Section:

$A = 6.77\ in^2$

$d = 8\ in$

$t_w = 0.441\ in$

$b_f = 4.171\ in$

$r_T = 0.95$

$S_x = 16.2\ in^3$

S.O. No.

Subject: Hart-Miller Island - STEEL HOIST DESIGN

Sheet No. 3 of 6

Drawing No.

Computed by EVF Checked By Date 6/7/02

Baker

Actual $f_b = \frac{M}{S_x} = \frac{12{,}125(12)}{16.2} = 8981 \frac{\#}{in^2} = 8.98$ ksi

$L_c = 4.4$

$L_u = 10.3$

Unbraced Length, $L_b = 5'$

$4.4 < L_b = 5 < 10.3$, ∴ inadequate lateral support

$\frac{l}{r_T} = \frac{5(12)}{0.95} = 63.2$

$\sqrt{\frac{102(10)^3 C_b}{36}} = 53\sqrt{C_b} \xrightarrow{1} 53$

$\sqrt{\frac{510(10)^3 C_b}{36}} = 119\sqrt{C_b} \xrightarrow{1} 119$

$53 < \frac{l}{r_T} = 63.2 < 119$

(AISCS Eqn F1-6)

$$F_b = \left[\frac{2}{3} - \frac{F_y\left(\frac{l}{r_T}\right)^2}{1530(10)^3 C_b}\right]F_y = \left[\frac{2}{3} - \frac{36(63.2)^2}{1530(10)^3(1)}\right]36 = 20.6 \text{ ksi}$$

(AISCS Eqn F1-8)

$$F_b = \frac{170(10)^3 C_b}{\left(\frac{l}{r_T}\right)^2} = \frac{170(10)^3(1)}{(63.2)^2} = 42.6 \text{ ksi}$$

Allow. Tension $F_b = .60F_y = .60(36) = 21.6$ ksi

→ Use Allow. Comp. $F_b = 21.6$ ksi

Actual $f_b = 8.98$ ksi < 21.6 ksi (OK, safe in moment)

Note: Check for Shear was done, and section is safe in shear

* USE S 8 x 23 for Bridge

S.O. No. ______

Subject: Hart-Miller Island - STEEL HOIST DESIGN

Sheet No. 4 of 6

Drawing No. ______

Computed by EKF Checked By ______ Date 6/7/02

Baker

Design of Beam

$$Min.\ d = \frac{6(12)}{20} = 3.6''$$

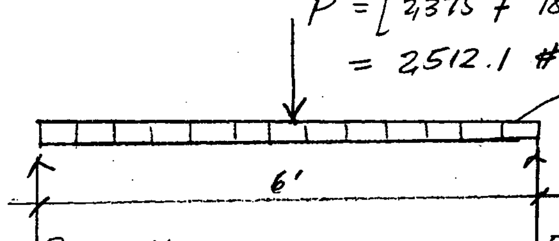
trolley

Bridge

$$P = \left[2{,}375 + \overbrace{18.4\left(5 + \frac{4.9}{2}\right)}\right]$$

$$= 2{,}512.1\ \#$$

$\omega = 20$ plf (assumed)



$R_1 = 1316$ $R_2 = 1316$

$$R_1 = R_2 = \frac{2512.1}{2} + \frac{20(6)}{2} = 1316\ \#$$

$$M_{midspan} = 1316(3) - 20(3)\left(\frac{3}{2}\right) = 3{,}858\ ft\text{-}\#$$

Try W6x25 Section

$A = 7.34$
$d = 6.38$
$t_w = 0.32$
$b_f = 6.08$
$r_T = 1.66$
$S_x = 16.7$

$L_c = 6.40'$ $L_u = 20'$

$L_b = 3'$, $\therefore$ adequately supported

$F_b = .66 F_y = .66(36) = 24$ ksi

$$f_b = \frac{3858(12)}{16.7} = 2772\ psi = 2.77\ ksi < 24\ ksi$$

(OK, safe in Moment)

Note: Check in Shear was done, and section is safe in shear

$\boxed{\text{* Use W6 x 25 for Beam}}$

S.O. No.

Subject: Hart-Miller Island - STEEL HOIST DESIGN

Sheet No. 5 of 6

Drawing No.

Computed by EKF Checked By Date 6/7/02

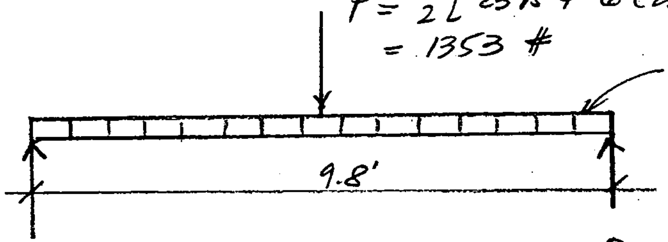
Baker

Design of Girder

trolley, Beam, Girder

$P = \frac{1}{2}[2375 + 6(25) + 9.8(18.4)]$
$= 1353$ #

$W = 20$ plf (assumed)



Min $d = \frac{9.8(12)}{20}$
$= 5.88''$

$R_1 = 774.5$ $R_2 = 774.5$

$$R_1 = R_2 = \frac{1353}{2} + \frac{20(9.8)}{2} = 774.5$$

$$M^{(+)}_{midspan} = 774.5\left(\frac{4.9}{2}\right) - 20(4.9)\left(\frac{4.9}{2}\right)$$
$$= 1657.4 \text{ ft \#}$$

Try W6x25 Section

$L_c = 6.40'$ $L_u = 20'$

$L_b = 4.9'$, $\therefore$ adequately supported

$F_b = .66F_y = 24$ ksi

$f_b = \frac{1657(12)}{16.7} = 1190.7$ psi $= 1.191$ ksi < 24 ksi

(OK, safe in moment)

Note: Check in shear was done, and section is safe in shear

* Use W6x25 for Girder

S.O. No. ____________

Subject: Hart-Miller Island - STEEL HOIST DESIGN

Sheet No. 6 of 6

Drawing No. ____________

Computed by EKF Checked By ____________ Date 6/7/02

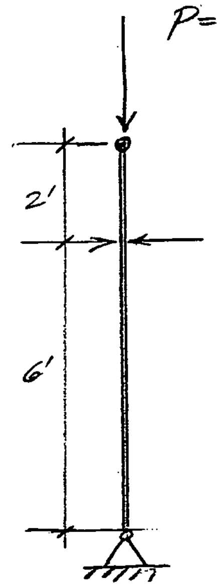
Baker

Design of Posts

$k = 2.0$

$$P = \frac{2{,}375}{2} + \frac{6(25)}{\cancel{2}}\cancel{(2)} + 23\left(5+\frac{4.9}{2}\right) + \frac{9.8(25)}{2} = 1631.4\ \#$$

trolley, beams, bridge, girder



$$\frac{kl}{r} = \frac{2(6)(12)}{1.45} = 99.3$$

$\Rightarrow F_a = 12.98$ ksi

Try 4 x 4 x 3/8 Square Tubing

$A = 5.08$ $\quad S = 5.35$

$I = 10.7$ $\quad r = 1.45$

Allow. load, $P_a = F_a A = 12.98(5.08)$

$= 65.9\ k > P_{actual} = 1.63\ k$

(ok)

* USE TS 4 x 4 x 3/8 POSTS

APPENDIX D

WATER DISTRIBUTION SYSTEM

6.2.1 Hydraulics

Pipe Size

S.O. No. 22939-014-0000 T.O.# 00220

Subject: HMI PUMP CALCS. II

Sheet No. 5 of 6

Drawing No.

Computed by TAB Checked By Date 12 MAR 02

Baker

$$h_{f_{SW}} = 12.06' + 10.44 \cdot \frac{(101.7') \cdot (864\ gpm)^{1.85}}{(140)^{1.85} \cdot (10'')^{4.8655}} = \boxed{12.48'}$$

$$h_{f_{UG}} = 5.89' + 10.44 \cdot \frac{(60.0') \cdot (468\ gpm)^{1.85}}{(140)^{1.85} \cdot (8'')^{4.8655}} = \boxed{6.13'}$$

$$h_{f_S} = 7.18' + 12.48' = \boxed{19.66'}$$

FROM PREVIOUS CALCS. $h_v + h_p = \frac{70 \cdot 2.31}{1} = 161.7'$

$$Q_{INTAKE} = Q_{SPRINKLER} + Q_{FILL}$$
$$= 1400\ gpm + 1300\ gpm$$
$$= 2700\ gpm$$

$$A_{INTAKE} = \frac{Q}{V}$$

MAX ALLOWABLE V FOR HDPE IS 6 ft/sec

$$A_{INTAKE} = \frac{2700 \frac{gal}{min} \cdot \frac{1\ min}{60\ sec} \cdot \frac{0.1337\ ft^3}{gal}}{6\ ft/sec} = 1.0028\ ft^2$$

$$d = 2 \cdot \sqrt{\frac{A}{\pi}} = 2 \cdot \sqrt{\frac{1.0028\ ft^2}{\pi}} = 1.1299\ ft \cdot \frac{12''}{ft} = 13.56'' \approx 14''\ \phi$$

$$l_{INTAKE} = 110'$$

MINOR LOSSES

			EQ PIPE LENGTH	L_{eq}
90° ELBOW	1	14"	30 - D	35.0'

$$h_{f_{INTAKE}} = 10.44 \cdot \frac{(110' + 35') \cdot (2700\ gpm)}{(140)^{1.85} \cdot (14'')^{4.8655}} = 0.96'$$

INTAKE SCREEN LOSSES = .75'

$$h_{f_{INTAKE}} = .75' + .96' = 1.71'$$

$$h_s = 23' + 1.71' = \boxed{24.71'}$$

S.O. No. 22939-014-0000 T.O.# 00220

Subject: HMI PUMP CALCS. II

Baker

Sheet No. 6 of 6

Drawing No.

Computed by TAB Checked By Date 12 MAR 02

$$TDH_s = h_{s_s} + h_{f_s} + h_{v_s} + h_{P_s}$$

$$TDH_s = 24.71' + 19.66' + 161.7' = 206.07' \text{ @ } 1332 \text{ gpm}$$

Floatation/Anchoring System

S.O. No. 22939-014-0000

Subject: FLOTATION CALCULATIONS

Sheet No. 2 of 3

Drawing No.

Computed by [signature] Checked By

Date 3 APR 02

∴ THE INTAKE PIPE REQUIRES NO ADDITIONAL ANCHORING

INTAKE SCREEN AND REDUCER

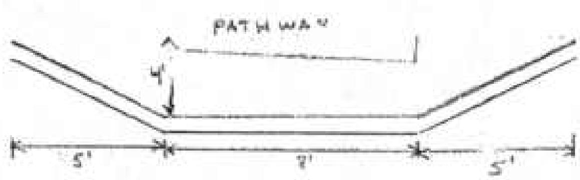
$V_{REDUCER} + V_{INTAKE\ SCREEN} = 22.0\ ft^3 + 22.0\ ft^3 = 44.0\ ft^3$

$F_{BUOYANCY} = 44.0\ ft^3 \cdot 64.0\ lbs/ft^3 = 2816\ lbs. \uparrow$

$W_{CONC.\ REQ'D} \downarrow = \dfrac{F_{BUOYANCY}}{\gamma_{CONC\ SUBMERGED}} = \dfrac{2816\ lbs}{87.6\ \frac{lbs}{ft^3}} = \boxed{32.2\ ft^3}$

PIPING UNDER PATHWAYS

ASSUMING GROUND IS COMPLETELY SATURATED, WORST CASE



$V_{PIPE} = \pi r^2 h = \pi \left(7'' \cdot \frac{1ft}{12''}\right)^2 18ft = 19.24\ ft^3$

$F_{BUOYANCY} = V_{PIPE} \cdot \gamma_{SEAWATER} = 19.24\ ft^3 \cdot 64.0\ lbs/ft^3 = 1231.50\ lbs \uparrow$

$W_{INUNDATED\ BACKFILL} = w - \left(\frac{w}{SG \cdot 64} \times 64\right) = 110 - \left(\frac{110}{2.65}\right) = 68.49\ lbs/ft^3$

$V_{BACKFILL} = l \cdot w \cdot h = 8\ ft \cdot \left(14'' \cdot \frac{1ft}{12''}\right) \cdot 4\ ft + 5ft\left(14'' \cdot \frac{1ft}{12''}\right) \cdot 4'$

$V_{BACKFILL} = 37.33\ ft^3 + 23.33\ ft^3 = 60.7\ ft^3$

SAFETY FACTOR OF 1.5

$F_{BACKFILL} = \dfrac{W_{IB}}{S.F.} \cdot V_{BACKFILL} = \dfrac{68.49\ lbs/ft^3}{1.5} \cdot 60.7\ ft^3 = 2771.6\ lbs.$

∴ $F_{BUOYANCY} < F_{BACKFILL}$ THUS NO ANCHORING REQUIRED

S.O. No. 22939-014-000

Subject: FLOTATION CALCULATIONS

Sheet No. 3 of 3

Drawing No.

Computed by SGB Checked By Date 4 APR 02

Baker

CONCRETE ANCHOR SHAPES

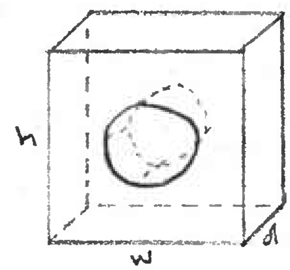
$V_{\text{CONC. INTAKE}} = 32.2 \text{ ft}^3 = h \cdot w \cdot d$

ASSUME $h = w = 4'$

$$d = \frac{32.2 \text{ ft}^3}{4 \text{ ft} \cdot 4 \text{ ft}} - \pi \left(7'' \cdot \frac{1 \text{ ft}}{12''}\right)^2 \cdot d$$

$d + 1.07 d = 2.0125 \text{ ft}$

$$d = \frac{2.0125 \text{ ft}}{2.07} = .97 \text{ ft} \approx 1 \text{ ft}$$



$\therefore$ $h = 4'$, $w = 4'$, & $d = 1$ ft ANCHOR

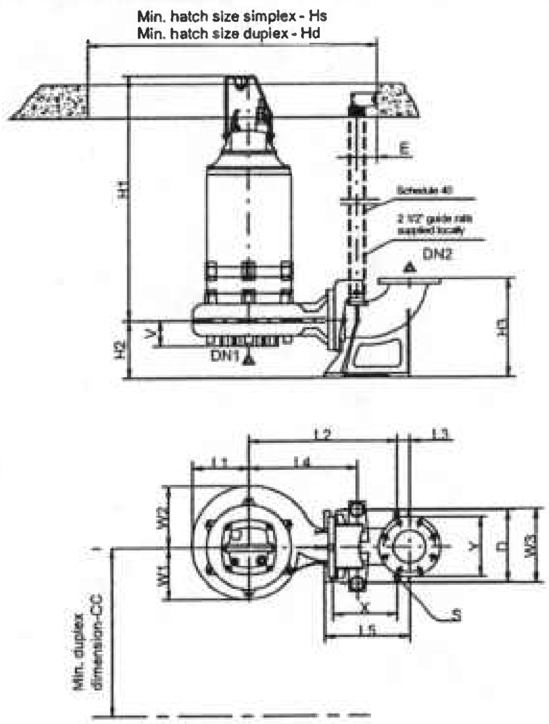
6.2.2 Pump Station

Selection of Pump Type

Wastewater pumps

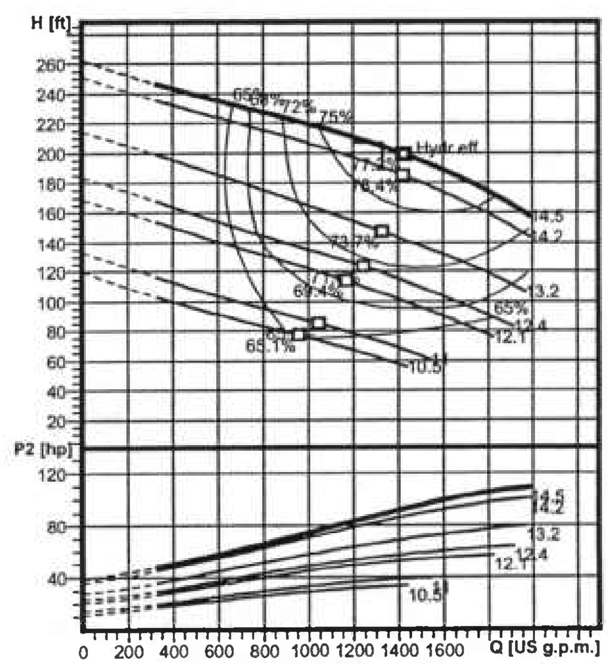
K 107 F-CB3368

60 Hz



Wet sump installation with base elbow

Testnorm H.I.



K 107-CB3-AC 60Hz

Dimensions [inch]

H1	H2	H3	V	DN1	DN2
H1	9¹³/₁₆	16³/₄	5¹/₈	4	6
E	W1	W2	W3	L1	L2
3³/₄	9¹³/₁₆	11¹/₄	13³/₈	10¹/₁₆	26³/₄
L3	L4	L5	X	Y	D
1¹⁵/₁₆	19⁷/₈	13³/₈	9¹³/₁₆	10¹/₄	12⁵/₈
S	Hs	Hd	CC		
¹⁵/₁₆	30X36	36X60	293/16		

Operating data specification at duty point			
Head	207 ft	Flow	1332 US g.p.m.
No. of pumps	1	Nature of system	Single head pump
Temperature	68 °F	Fluid	Water
Viscosity	0.0000108 ft²/s	Density	62.4 lb/ft³

Pump data			
Make	PUMPEX	Type	K 107 F-CB3368
Series	K	Impeller type	Dual channel impeller
Free passage	3 1/16 inch	Impeller size	14 1/2 inch
Head	205 ft	Flow	1324 US g.p.m.
Operating speed	1780 rpm	Shaft power	88.8 hp

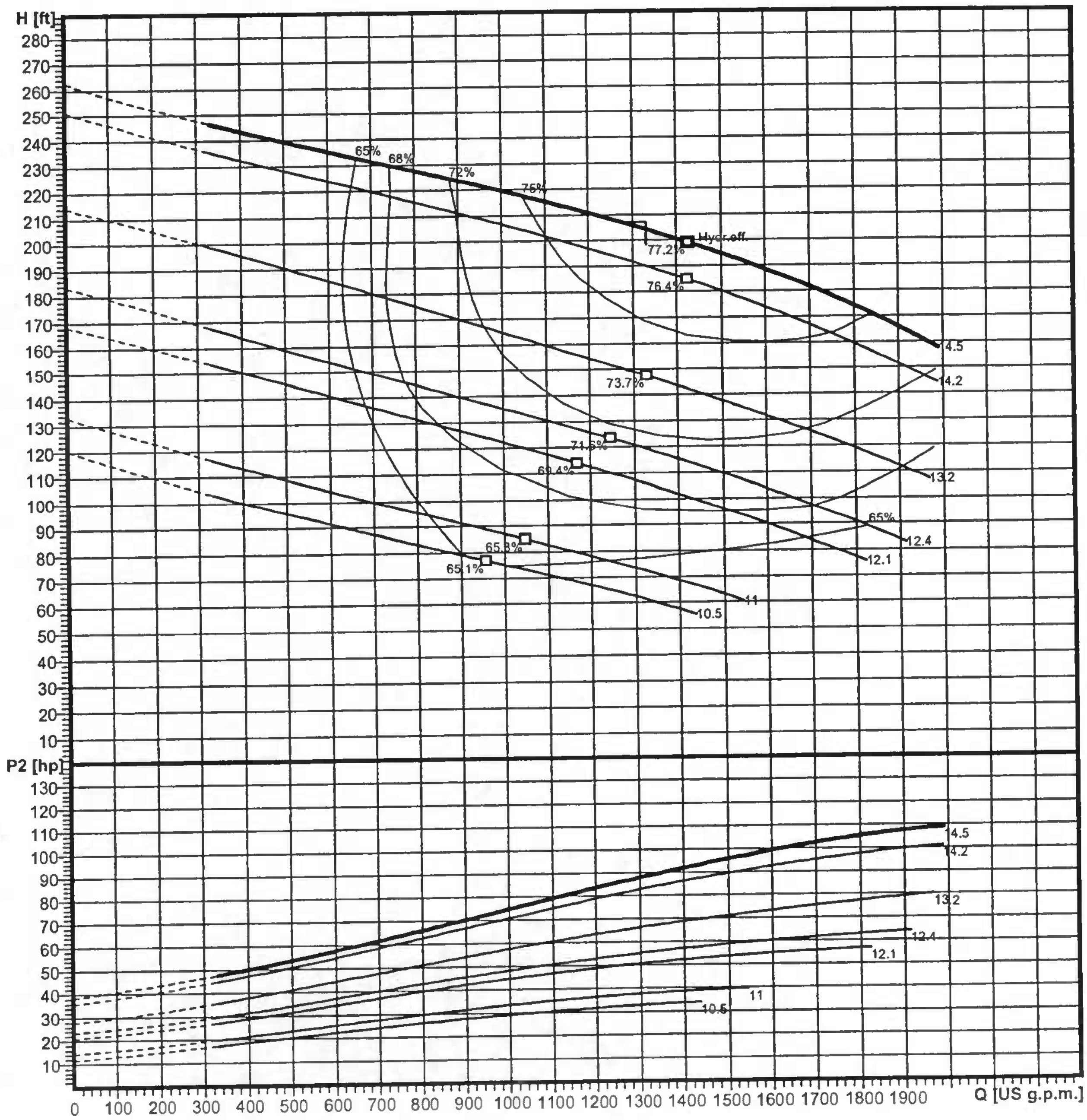
Motor data			
Rated voltage	460 V	Rated power P2	130 hp
Nominal speed	1780 rpm	Rated current	149 A
Degree of protection	IP68	Frequency	60 Hz
Efficiency	94 %	Insulation class	F
		Power factor	0.87

Wastewater pumps

K 107 F-CB3368

60 Hz

Density	Viscosity	Testnorm	Nominal speed	Sel. speed	Date
62.4 lb/ft³	0.0000108 ft²/s	H.I.	1780 rpm	1780 rpm	March 25, 2002
Impeller Channel		Impeller size 14 1/2 inch			

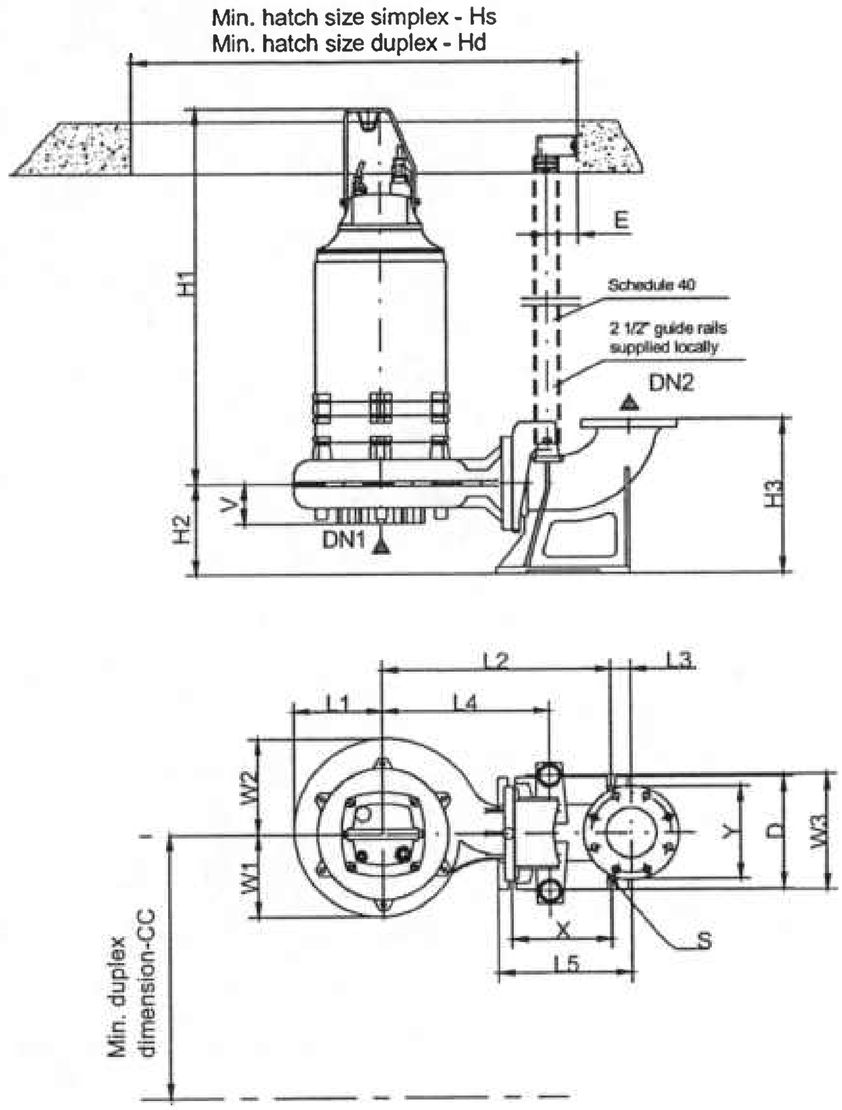


K 107-CB3-AC 60Hz

Wastewater pumps

K 107 F-CB3368

60 Hz



Wet sump installation with base elbow

Dimensions [inch]					
H1 H1	H2 $9^{13}/_{16}$	H3 $16^{3}/_{4}$	V $5^{1}/_{8}$	DN1 4	DN2 6
E $3^{3}/_{4}$	W1 $9^{13}/_{16}$	W2 $11^{1}/_{4}$	W3 $13^{3}/_{8}$	L1 $10^{1}/_{16}$	L2 $26^{3}/_{4}$
L3 $1^{15}/_{16}$	L4 $19^{7}/_{8}$	L5 $13^{3}/_{8}$	X $9^{13}/_{16}$	Y $10^{1}/_{4}$	D $12^{5}/_{8}$
S $^{15}/_{16}$	Hs 30X36	Hd 36X60	CC 293/16		

Wastewater pumps

K 107 F-CB3368

PUMPEX WASTEWATER PUMP K 107
60 Hz

Pump	Motor Power rating	Poles	Discharge-Connection
K 107 CA3368	98 Hp	4	Ansi 4"/6"
K 107 CA3365	80 Hp	4	Ansi 4"/6"
K 107 CA3353	66 Hp	4	Ansi 4"/6"
K 107 CA3341	56 Hp	4	Ansi 4"/6"
K 107 CA3315	40 Hp	4	Ansi 4"/6"
K 107 CA3305	40 Hp	4	Ansi 4"/6"
K 107 CB3368	130 Hp	4	Ansi 4"/6"
K 107 CB3360	98 Hp	4	Ansi 4"/6"
K 107 CB3335	80 Hp	4	Ansi 4"/6"
K 107 CB3315	66 Hp	4	Ansi 4"/6"
K 107 CB3307	56 Hp	4	Ansi 4"/6"
K 107 CB3280	40 Hp	4	Ansi 4"/6"
K 107 CB3267	34 Hp	4	Ansi 4"/6"
K 107 VA3367	98 Hp	4	Ansi 4"/6"
K 107 VA3342	80 Hp	4	Ansi 4"/6"
K 107 VA3318	66 Hp	4	Ansi 4"/6"
K 107 VA3298	56 Hp	4	Ansi 4"/6"
K 107 VA3285	56 Hp	4	Ansi 4"/6"
K 107 VB3342	98 Hp	4	Ansi 4"/6"
K 107 VB3335	98 Hp	4	Ansi 4"/6"
K 107 VB3322	80 Hp	4	Ansi 4"/6"
K 107 VB3308	66 Hp	4	Ansi 4"/6"
K 107 VB3294	56 Hp	4	Ansi 4"/6"
K 107 VB3290	56 Hp	4	Ansi 4"/6"
K 107 CA5368	28 Hp	6	Ansi 4"/6"
K 107 CA5348	18 Hp	6	Ansi 4"/6"
K 107 CA5328	14 Hp	6	Ansi 4"/6"
K 107 CA5305	14 Hp	6	Ansi 4"/6"
K 107 CB5368	40 Hp	6	Ansi 4"/6"
K 107 CB5354	28 Hp	6	Ansi 4"/6"
K 107 CB5316	18 Hp	6	Ansi 4"/6"
K 107 CB5296	14 Hp	6	Ansi 4"/6"
K 107 CB5275	14 Hp	6	Ansi 4"/6"
K 107 CB5250	14 Hp	6	Ansi 4"/6"
K 107 VA5368	40 Hp	6	Ansi 4"/6"
K 107 VA5364	28 Hp	6	Ansi 4"/6"
K 107 VA5310	18 Hp	6	Ansi 4"/6"
K 107 VA5285	18 Hp	6	Ansi 4"/6"
K 107 VB5342	40 Hp	6	Ansi 4"/6"
K 107 VB5334	28 Hp	6	Ansi 4"/6"
K 107 VB5302	18 Hp	6	Ansi 4"/6"
K 107 VB5290	18 Hp	6	Ansi 4"/6"
K 107 CA7368	11 Hp	8	Ansi 4"/6"
K 107 CA7352	11 Hp	8	Ansi 4"/6"
K 107 CA7335	11 Hp	8	Ansi 4"/6"
K 107 CA7305	11 Hp	8	Ansi 4"/6"

Wastewater pumps

K 107 F-CB3368

K 107 CB7368	18 Hp	8	Ansi 4"/6"
K 107 CB7354	11 Hp	8	Ansi 4"/6"
K 107 CB7316	11 Hp	8	Ansi 4"/6"
K 107 CB7296	11 Hp	8	Ansi 4"/6"
K 107 CB7275	11 Hp	8	Ansi 4"/6"
K 107 CB7250	11 Hp	8	Ansi 4"/6"
K 107 VA7368	18 Hp	8	Ansi 4"/6"
K 107 VA7358	11 Hp	8	Ansi 4"/6"
K 107 VA7325	11 Hp	8	Ansi 4"/6"
K 107 VA7285	11 Hp	8	Ansi 4"/6"
K 107 VB7342	18 Hp	8	Ansi 4"/6"
K 107 VB7330	11 Hp	8	Ansi 4"/6"
K 107 VB7315	11 Hp	8	Ansi 4"/6"
K 107 VB7290	11 Hp	8	Ansi 4"/6"

Suction-side:

Wet	Dry
Ansi 4"	Ansi 6"

Motordata :
Insulation Class F (310° F) . Built-in thermal contacts.
Built-in moisture sensor.
FM Explosion Proof - Class 1, Div.1, Gr. C&D (optional).

Power rating	Motor-efficiency	Power-factor	Speed (rpm)	Nom.current 230V (Amps)	Nom.current 460V (Amps)	Start current Ist/In
34 Hp-4	0.89	0.87	1780	82.3	41.2	7.0
40 Hp-4	0.88	0.90	1780	94.4	47.2	7.0
56 Hp-4	0.91	0.90	1780	128	64.1	6.7
66 Hp-4	0.925	0.89	1780	150	75	6.8
80 Hp-4	0.92	0.89	1780	183	91.5	7.2
98 Hp-4	0.91	0.88	1780	229	115	6.9
130 Hp-4	0.94	0.87	1780	298	149	6.6
14 Hp-6	0.80	0.77	1180	42.4	21.2	6.5
18 Hp-6	0.83	0.80	1180	50.7	25.3	7.0
28 Hp-6	0.87	0.84	1180	71.8	35.9	6.0
40 Hp-6	0.88	0.88	1180	96.6	48.3	6.4
11 Hp-8	0.77	0.75	880	35.6	17.8	5.5
18 Hp-8	0.88	0.75	880	51.0	25.5	6.0

Impellers :
CA : 1-channel impeller. Free passage 3 1/16".
CB : 2-channel impeller. Free passage 3 1/16".
VA : Vortex impeller. Free passage 2 3/8".
VB : Recessed vortex impeller. Free passage 3 3/8".

Cables:

Motor	D.O.L.-start 460V
34 Hp-4	4x10 sq.mm.
40 Hp-4	4x10 sq.mm.
56 Hp-4	4x16 sq.mm.
66 Hp-4	4x25 sq.mm.
80 Hp-4	4x25 sq.mm.

Wastewater pumps

K 107 F-CB3368

98 Hp-4	4x35 sq.mm.
130 Hp-4	4x70 sq.mm.
14 Hp-6	4x6 sq.mm.
18 Hp-6	4x6 sq.mm.
28 Hp-6	4x6 sq.mm.
40 Hp-6	4x10 sq.mm.
11 Hp-8	4x6 sq.mm.
18 Hp-8	4x6 sq.mm.

Shaft seal :
Double mechanical seal in oil bath.
Primary seal : silicon carbide on silicon carbide.
Secondary seal : carbon on stainless steel.

Bearings :
Upper: single-row deep groove ball bearing.
Lower: two angular contact ball bearings.

Oil and cooling fluid:
Oil to pump with internal cooling : Energol XP 150
Oil to pump without internal cooling : Energol HLP D 46

Oil quantity:

Pump	Pump with internal cooling		Pump without internal cooling
	oil	cooling fluid	
K 107-34 Hp-4	6.3 pints	74.0 pints	12.7 pints
K 107-40 Hp-4	6.3 pints	74.0 pints	12.7 pints
K 107-56 Hp-4	6.3 pints	55.0 pints	21.1 pints
K 107-66 Hp-4	8.5 pints	59.2 pints	21.1 pints
K 107-80 Hp-4	8.5 pints	67.6 pints	23.2 pints
K 107-98 Hp-4	9.5 pints	74.0 pints	23.2 pints
K 107-130 Hp-4	10.5 pints	121.0 pints	29.8 pints
K 107-14 Hp-6	5.3 pints	80.3 pints	12.7 pints
K 107-18 Hp-6	5.3 pints	80.3 pints	12.7 pints
K 107-28 Hp-6	6.3 pints	74.0 pints	12.7 pints
K 107-40 Hp-6	6.3 pints	55.0 pints	21.1 pints
K 107-11 Hp-8	5.3 pints	80.3 pints	12.7 pints
K 107-18 Hp-8	6.3 pints	74.0 pints	12.7 pints

Materials :
Castings : Grey cast iron ASTM A48 Class 30 B.
Rotor shaft : Steel AISI C 1045.
Nuts and bolts : Acidproof steel AISI 316.
O-rings : Nitrile rubber (Viton in shaft seals).

Weights :

Pump	K 107 F	K 107 T	K 107 P
K 107 34 Hp-4	783 lbs	970 lbs	827 lbs
K 107 40 Hp-4	827 lbs	1014 lbs	871 lbs
K 107 56 Hp-4	849 lbs	1025 lbs	893 lbs
K 107 66 Hp-4	926 lbs	1113 lbs	970 lbs
K 107 80 Hp-4	1003 lbs	1190 lbs	1047 lbs

Wastewater pumps

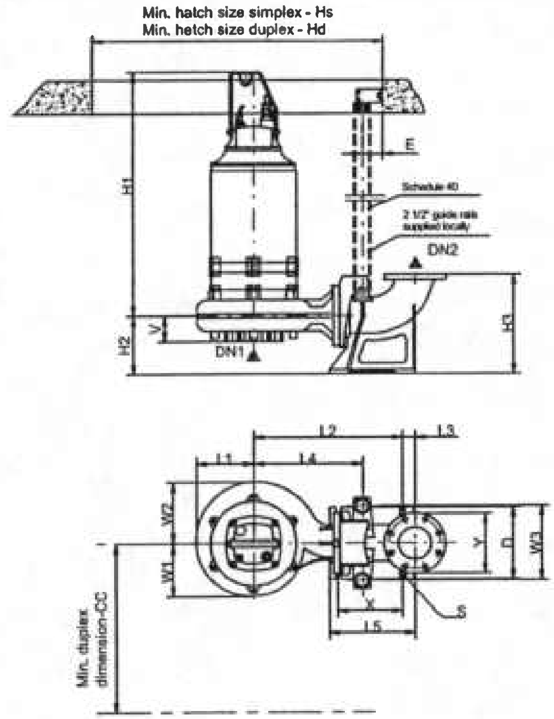
K 107 F-CB3368

K 107 98 Hp-4	1157 lbs	1356 lbs	1201 lbs
K 107 130 Hp-4	1753 lbs	1951 lbs	1797 lbs
K 107-14 Hp-6	716 lbs	904 lbs	761 lbs
K 107-18 Hp-6	716 lbs	904 lbs	761 lbs
K 107-28 Hp-6	827 lbs	1014 lbs	871 lbs
K 107-40 Hp-6	849 lbs	1025 lbs	893 lbs
K 107-11 Hp-8	716 lbs	904 lbs	761 lbs
K 107-18 Hp-8	827 lbs	1014 lbs	871 lbs
Discharge bracket 6"	154 lbs	-	-

Wastewater pumps

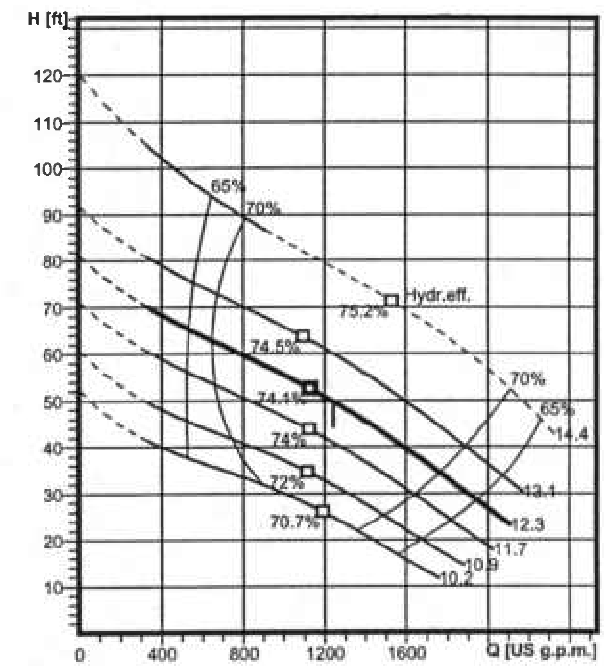
K 154 F-CD5312

60 Hz



Wet sump installation with base elbow

Testnorm H.I.



K 154-CD5-AC 60Hz

Dimensions [inch]

H1	H2	H3	V	DN1	DN2
42 11/16	10 13/16	18 11/16	4 15/16	6	6
E	W1	W2	W3	L1	L2
3 3/4	10 1/16	11 7/16	13 3/4	10 5/8	27 3/16
L3	L4	L5	X	Y	D
2 3/8	19 7/8	15 3/4	11 13/16	11	13 3/8
S	Hs	Hd	CC		
15/16	30X36	60X36	293/8		

Operating data specification at duty point

Head	50 ft	Flow	1245 US g.p.m.
Nature of system	Single head pump	Static head	21.3 ft
Fluid	Water	No. of pumps	1
Density	62.4 lb/ft³	Temperature	68 °F
		Viscosity	0.0000108 ft²/s

Pump data

Make	PUMPEX	Type	K 154 F-CD5312
Series	K	Impeller type	Dual channel impeller
Free passage	3 inch	Impeller size	12 5/16 inch
Head	49.8 ft	Flow	1240 US g.p.m.
		Operating speed	1185 rpm

Motor data

Rated voltage	460 V	Rated power P2	28 hp
Nominal speed	1170 rpm	Rated current	35.9 A
Degree of protection	IP68	Frequency	60 Hz
Efficiency	87 %	Insulation class	F
		Power factor	0.84

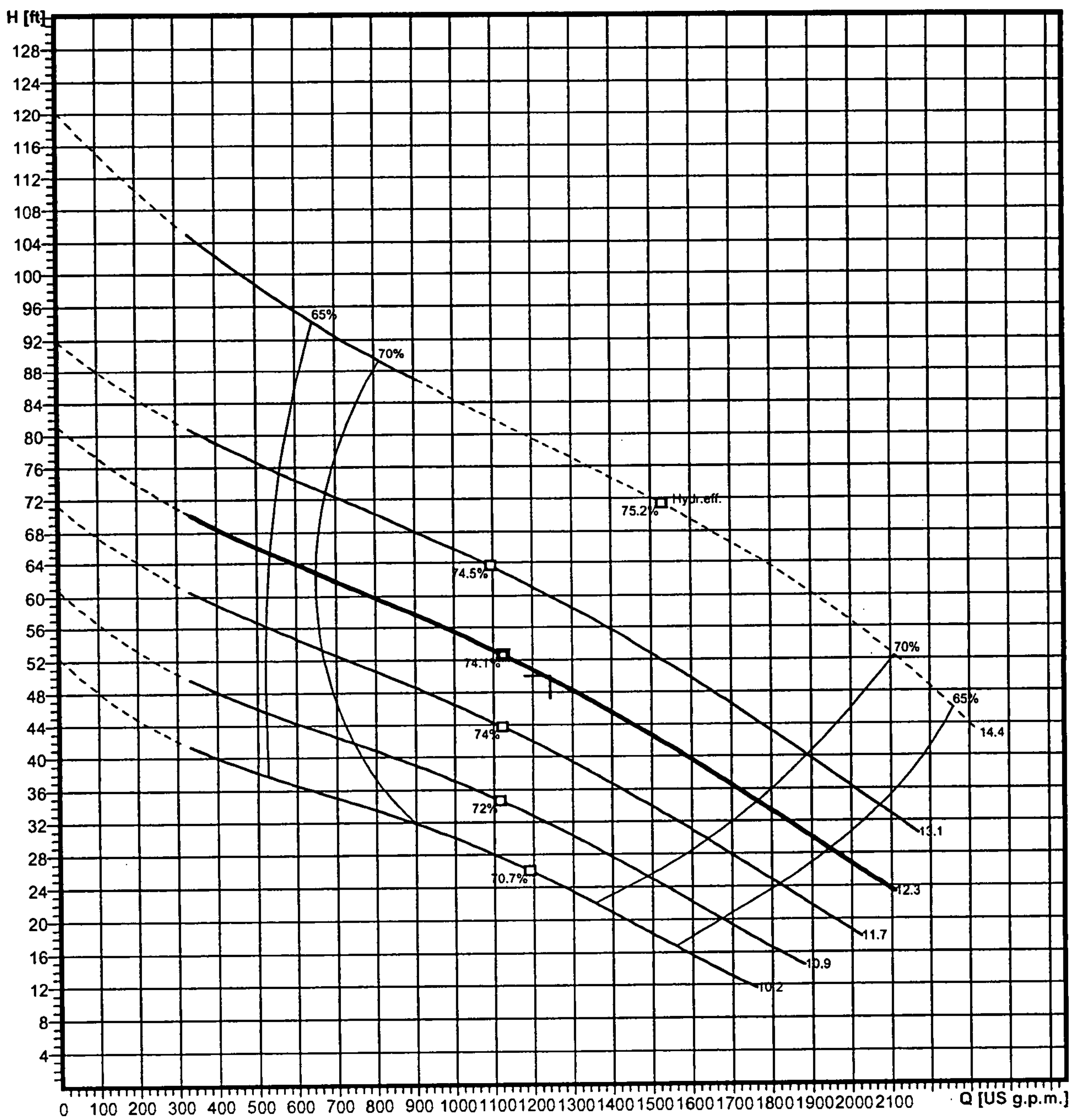
PUMPEX

Wastewater pumps

K 154 F-CD5312

60 Hz

Density 62.4 lb/ft³	Viscosity 0.0000108 ft²/s	Testnorm H.I.	Nominal speed 1170 rpm	Sel. speed 1185 rpm	Date February 06, 2002
Impeller Channel		Impeller size 12 5/16 inch			

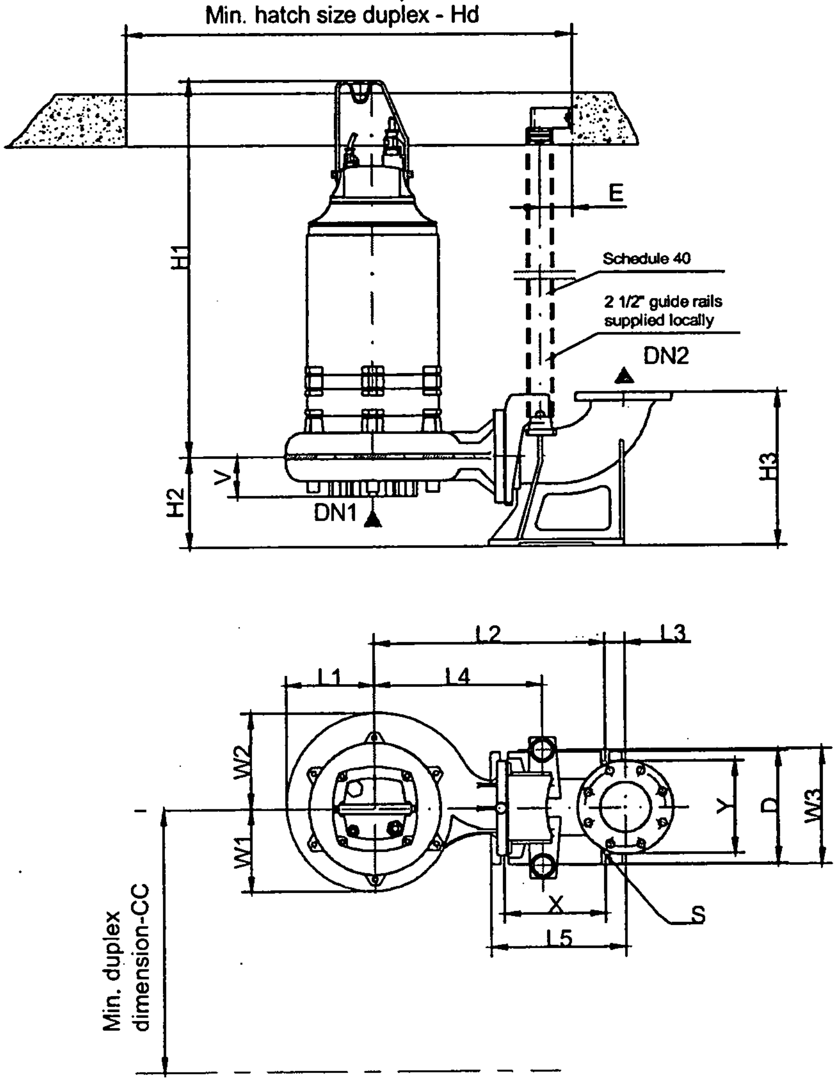


K 154-CD5-AC 60Hz

Wastewater pumps

K 154 F-CD5312

60 Hz



Wet sump installation with base elbow

Dimensions [inch]					
H1 $42^{11}/_{16}$	H2 $10^{13}/_{16}$	H3 $18^{11}/_{16}$	V $4^{15}/_{16}$	DN1 6	DN2 6
E $3^{3}/_{4}$	W1 $10^{1}/_{16}$	W2 $11^{7}/_{16}$	W3 $13^{3}/_{4}$	L1 $10^{5}/_{8}$	L2 $27^{3}/_{16}$
L3 $2^{3}/_{8}$	L4 $19^{7}/_{8}$	L5 $15^{3}/_{4}$	X $11^{13}/_{16}$	Y 11	D $13^{3}/_{8}$
S $^{15}/_{16}$	Hs 30X36	Hd 60X36	CC 293/8		

Wastewater pumps

PUMPEX WASTEWATER PUMP K 154
60 Hz

Pump	Motor Power rating	Poles	Discharge-Connection	Suction-side
K 154 CC3365	98 Hp	4	Ansi 6"	Ansi 6"
K 154 CC3356	80 Hp	4	Ansi 6"	Ansi 6"
K 154 CC3340	66 Hp	4	Ansi 6"	Ansi 6"
K 154 CC3326	56 Hp	4	Ansi 6"	Ansi 6"
K 154 CC3296	40 Hp	4	Ansi 6"	Ansi 6"
K 154 CC3290	40 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3365	155 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3359	130 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3336	98 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3320	80 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3300	66 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3290	56 Hp	4	Ansi 6"	Ansi 6"
K 154 CD3265	40 Hp	4	Ansi 6"	Ansi 6"
K 154 VA3365	98 Hp	4	Ansi 6"	Ansi 6"
K 154 VA3358	98 Hp	4	Ansi 6"	Ansi 6"
K 154 VA3323	80 Hp	4	Ansi 6"	Ansi 6"
K 154 VA3300	80 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3340	130 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3325	98 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3312	80 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3292	66 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3270	56 Hp	4	Ansi 6"	Ansi 6"
K 154 VB3250	56 Hp	4	Ansi 6"	Ansi 6"
K 154 CC5365	28 Hp	6	Ansi 6"	Ansi 6"
K 154 CC5335	18 Hp	6	Ansi 6"	Ansi 6"
K 154 CC5309	14 Hp	6	Ansi 6"	Ansi 6"
K 154 CC5290	14 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5365	56 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5363	40 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5332	28 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5296	18 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5277	14 Hp	6	Ansi 6"	Ansi 6"
K 154 CD5260	14 Hp	6	Ansi 6"	Ansi 6"
K 154 VA5365	40 Hp	6	Ansi 6"	Ansi 6"
K 154 VA5359	28 Hp	6	Ansi 6"	Ansi 6"
K 154 VA5300	28 Hp	6	Ansi 6"	Ansi 6"
K 154 VB5340	40 Hp	6	Ansi 6"	Ansi 6"
K 154 VB5325	28 Hp	6	Ansi 6"	Ansi 6"
K 154 VB5286	18 Hp	6	Ansi 6"	Ansi 6"
K 154 VB5250	14 Hp	6	Ansi 6"	Ansi 6"
K 154 CC7365	11 Hp	8	Ansi 6"	Ansi 6"
K 154 CC7330	11 Hp	8	Ansi 6"	Ansi 6"
K 154 CC7290	11 Hp	8	Ansi 6"	Ansi 6"
K 154 CD7365	18 Hp	8	Ansi 6"	Ansi 6"

Wastewater pumps

K 154 F-CD5312

K 154 CD7328	11 Hp	8	Ansi 6"	Ansi 6"
K 154 CD7295	11 Hp	8	Ansi 6"	Ansi 6"
K 154 CD7260	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VA7365	18 Hp	8	Ansi 6"	Ansi 6"
K 154 VA7345	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VA7315	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VA7300	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VB7340	18 Hp	8	Ansi 6"	Ansi 6"
K 154 VB7320	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VB7300	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VB7278	11 Hp	8	Ansi 6"	Ansi 6"
K 154 VB7250	11 Hp	8	Ansi 6"	Ansi 6"

Motordata :
Insulation Class F (310° F) . Built-in thermal contacts.
Built-in moisture sensor.
FM Explosion Proof - Class 1, Div.1, Gr. C&D (optional).

Power rating	Motor-efficiency	Power-factor	Speed (rpm)	Nom.current 230V (Amps)	Nom.current 460V (Amps)	Start current Ist/In
40 Hp -4	0.88	0.90	1780	94.4	47.2	7.0
56 Hp -4	0.91	0.90	1780	128	64.1	6.7
66 Hp -4	0.925	0.89	1780	150	75	6.8
80 Hp -4	0.92	0.89	1780	183	91.5	7.2
98 Hp -4	0.91	0.88	1780	229	115	6.9
130 Hp -4	0.94	0.87	1780	298	149	6.6
155 Hp -4	0.945	0.88	1780	349	174	6.9
14 Hp -6	0.80	0.77	1180	42.4	21.2	6.5
18 Hp -6	0.83	0.80	1180	50.7	25.3	7.0
28 Hp -6	0.87	0.84	1180	71.8	35.9	6.0
40 Hp -6	0.88	0.88	1180	96.6	48.3	6.4
56 Hp -6	0.91	0.88	1180	131	65.5	6.5
11 Hp -8	0.77	0.75	880	35.6	17.8	5.5
18 Hp -8	0.88	0.75	880	51.0	25.5	6.0

Impellers :
CC : 1-channel impeller. Free passage 4".
CD : 2-channel impeller. Free passage 3" x 4".
VA : Vortex impeller. Free passage 3".
VB : Recessed vortex impeller. Free passage 5" .

Cables:

Motor	D.O.L.-start 460 V
40 Hp -4	4x10 sq.mm.
56 Hp -4	4x16 sq.mm.
66 Hp -4	4x25 sq.mm.
80 Hp -4	4x25 sq.mm.
98 Hp -4	4x35 sq.mm.
130 Hp-4	4x70 sq.mm.
155 Hp-4	2x4x35 sq.mm.
14 Hp -6	4x6 sq.mm.
18 Hp -6	4x6 sq.mm.
28 Hp -6	4x6 sq.mm.

Wastewater pumps

K 154 F-CD5312

40 Hp -6	4x10 sq.mm.
56 Hp -6	4x16 sq.mm.
11 Hp -8	4x6 sq.mm.
18 Hp -8	4x6 sq.mm.

Shaft seal :
Double mechanical seal in oil bath.
Primary seal : silicon carbide on silicon carbide.
Secondary seal : carbon on stainless steel.

Bearings :
Upper: single-row deep groove ball bearing.
Lower: two angular contact ball bearings.

Oil and cooling fluid:
Oil to pump with internal cooling : Energol XP 150
Oil to pump without internal cooling : Energol HLP D 46

Oil quantity:

Pump	Pump with internal cooling		Pump without internal cooling
	oil	cooling fluid	
K 154-40 Hp -4	6.3 pints	74.0 pints	12.7 pints
K 154-56 Hp -4	6.3 pints	55.0 pints	21.1 pints
K 154-66 Hp -4	8.5 pints	59.2 pints	21.1 pints
K 154-80 Hp -4	8.5 pints	67.6 pints	23.2 pints
K 154-98 Hp -4	9.5 pints	74.0 pints	23.2 pints
K 154-130 Hp -4	10.6 pints	120.5 pints	29.6 pints
K 154-155 Hp -4	10.6 pints	120.5 pints	29.6 pints
K 154-14 Hp -6	5.3 pints	80.3 pints	12.7 pints
K 154-18 Hp -6	5.3 pints	80.3 pints	12.7 pints
K 154-28 Hp -6	6.3 pints	74.0 pints	12.7 pints
K 154-40 Hp -6	6.3 pints	55.0 pints	21.1 pints
K 154-56 Hp -6	8.5 pints	67.6 pints	23.2 pints
K 154-11 Hp -8	5.3 pints	80.3 pints	12.7 pints
K 154-18 Hp -8	6.3 pints	74.0 pints	12.7 pints

Materials :
Castings : Grey cast iron ASTM A48 Class 30 B.
Rotor shaft : Steel AISI C 1045.
Nuts and bolts : Acidproof steel AISI 316.
O-rings : Nitrile rubber (Viton in shaft seals).

Weights :

Pump	K 154 F	K 154 T	K 154 P
K 154 40 Hp -4	794 lbs	992 lbs	838 lbs
K 154 56 Hp -4	860 lbs	1036 lbs	904 lbs
K 154 66 Hp -4	937 lbs	1124 lbs	981 lbs
K 154 80 Hp -4	1014 lbs	1213 lbs	1058 lbs
K 154 98 Hp -4	1168 lbs	1367 lbs	1213 lbs
K 154 130 Hp -4	1764 lbs	1962 lbs	1808 lbs
K 154 155 Hp -4	1841 lbs	2039 lbs	1885 lbs
K 154 28 Hp -6	794 lbs	992 lbs	838 lbs
K 154 40 Hp -6	860 lbs	1036 lbs	904 lbs

Wastewater pumps

K 154 F-CD5312

K 154 56 Hp -6	1014 lbs	1213 lbs	1058 lbs
K 154 11 Hp -8	728 lbs	915 lbs	772 lbs
K 154 18 Hp -8	794 lbs	992 lbs	838 lbs
Discharge bracket 6"	176 lbs	-	-

6.2.3 Lake Fill and MHS Force Main

Hydraulics

Size and Materials

S.O. No.

Subject: HMI PIPING CALCS.

Sheet No. 1 of 17

Drawing No.

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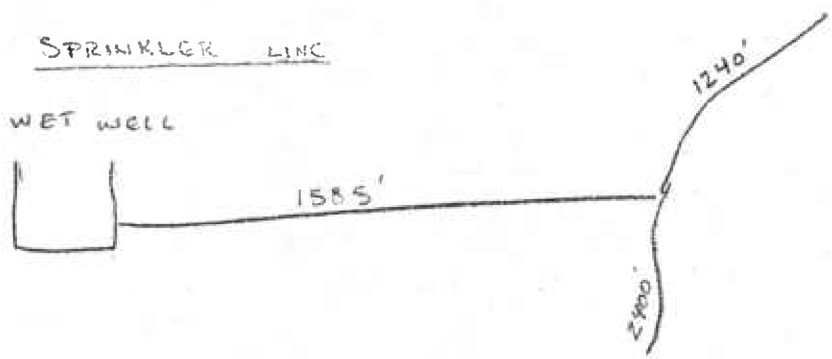
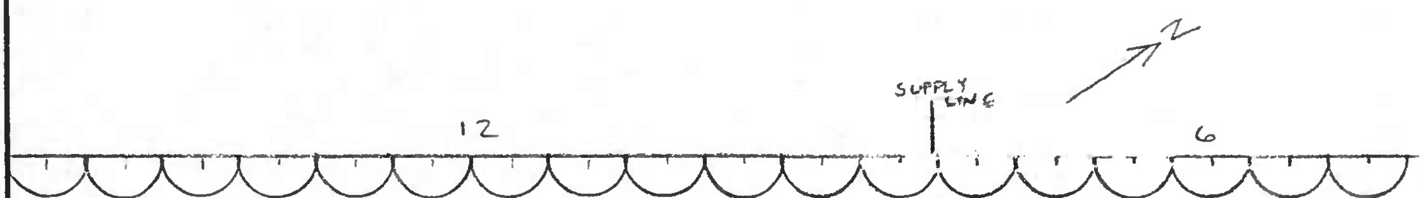
Baker

SPRINKLER LINE



IN ORDER TO MINIMIZE THE REQUIRED FLOW, I UTILIZED THE SMALLEST NOZZLE SIZE (.55") AND PRESSURE (44 PSI) REQUIRED AT THE NOZZLE. THIS ALLOWS A FLOW OF 57 gpm (PER NOZZLE) & A 105' THROW RADIUS.

(INFO OBTAINED FROM www.RAINBIRD.COM 3000 SERIES RAIN GUNS PERFORMANCE DATA)



REQUIRES 18 SPRINKLER HEADS

$$SH_{REQ} = \frac{2400' + 1240'}{2 \cdot (105')} = 17.33 \Rightarrow \boxed{18}$$

w/ 12 HEADS TO THE SW AND 2300' OF LATERAL AND 6 HEADS TO THE NE AND 1140' OF LATERAL

∴ EXPECT 2/3 OF ENTIRE FLOW TO SW
& 1/3 OF ENTIRE FLOW TO NE

S.O. No.

Subject: HMT PIPING CALCS.

Baker

Sheet No. 2 of 17

Drawing No.

Computed by TAB Checked By

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REQUIRED FLOW TO SPRINKLER.

$M_{IN} = 57$ gpm/head $\Rightarrow$ 60 gpm/head

$$Q_{REQ_S} = \frac{60 \text{ gpm}}{\text{head}} \cdot 18 \text{ heads} = 1080 \text{ gpm}$$

$$Q_{REQ_{S_{SW}}} = .66 (1080 \text{ gpm}) = 712.^8 \text{ gpm}$$

$$Q_{REQ_{S_{NE}}} = .33 (1080 \text{ gpm}) = 356.^4 \text{ gpm}$$

Use HAZEN-WILLIAMS NOMOGRAPH TO OBTAIN PRELIMINARY PIPE SIZE:

w/ $C = 140$ (HDPE PIPE), $Q_{REQ_{S_{SW}}} = 712.^8$ gpm $= 1.59$ ft^3/sec

AND $V = 3.25$ ft/sec

$$\boxed{d_{S_{SW}} = 8''}$$

w/ $C = 140$ (HDPE PIPE), $Q_{REQ_{S_{NE}}} = 356.^4$ gpm $= .794$ ft^3/sec

\& $V = 3.5$ ft/sec

$$\boxed{d_{S_{NE}} = 6''}$$

$$h_{L_{PIPE}} = 10.^{44} (L(ft))$$

S.O. No.

Subject: HMI PIPING CALCS.

Sheet No. 3 of 17

Drawing No.

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NEW SPRINKLER HEAD INFO FROM BIG GUN 75 SERIES WILL ALLOW A SMALLER Q. INFO OBTAINED FROM WWW.NELSONIRRIGATION.COM PERFORMANCE SPEC.S.

55 PSI 32 gpm 162' ϕ FOR A 0.4" NOZZLE SR75 24° TRAJECTORY

$\therefore$ SPRINKLER HEADS REQUIRED = $SH_{REQ} = \dfrac{2400' + 1240'}{162'} = 22.47 \approx \boxed{23}$

$Q_{REQ} = 23 \cdot 32 \text{ gpm} = 736 \text{ gpm}$

$SH_{SW} = \dfrac{2400'}{162'} = 15$

$SH_{NE} = 23 - 15 = 8$

SH ARE TO BE SPACED AT $\dfrac{2400' + 1240'}{23} = 157.4'$

ASSUMING $\frac{15}{23}$ FLOW TO SW & $\frac{8}{23}$ FLOW TO NE

$Q_{SW} = \frac{15}{23} \cdot 736 \text{ gpm} = 480 \text{ gpm}$ Q[illegible] = 736 gpm

$Q_{NE} = \frac{8}{23} \cdot 736 \text{ gpm} = 256 \text{ gpm}$

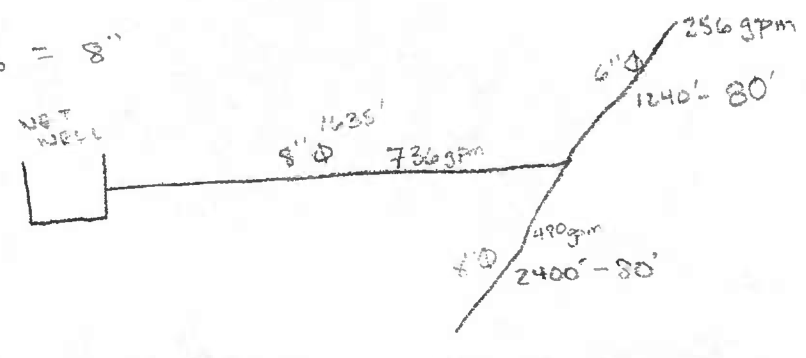
USE HAZEN-WILLIAMS NOMOGRAPH TO ESTIMATE PIPE SIZE.

USE ABOVE Q & KEEP $V < 5$ ft/sec & MINIMIZE h_L

$d_{NE} = 6''$ $d_{SM} = 8''$

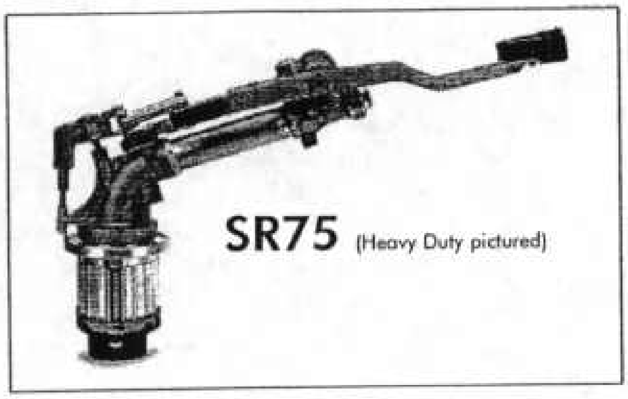
$d_{SW} = 8''$

$\therefore$



innovation in irrigation™ NELSON

75 SERIES BIG GUN® PERFORMANCE — U.S. UNITS



SR75 (Heavy Duty pictured)

Part Circle: SR75
Trajectories: 12°, 18°, 21°, 24°, 27°, 43°
Connection Options Include:
- 1 1/2" FNPT or FBSP
- 2" FNPT or FBSP
- 2 1/2" FNPT
- ANSI/DIN Flange (bolt on), Nelson Flange, Metric Flange

Lower Bearing Options:
- Heavy Duty

75 TAPER RING NOZZLE — TR75 — 24° TRAJECTORY

TR75 Taper Rings are ordered individually.
Specify size when ordering

	0.4"		0.45"		0.5"		0.55"		0.6"		0.65"		0.7"		0.75"		0.8"	
PSI	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.
25							42	143	50	162	59	158	69	164	80	[illegible]	93	178
30					37	155	45	155	55	162	64	169	75	178	87	183	99	188
35			32	151	40	161	49	169	59	175	69	187	81	192	93	198	106	204
40	27	147	35	157	43	168	52	177	63	186	74	194	87	200	98	208	112	217
45	29	152	37	164	46	176	56	185	67	194	79	202	91	209	104	218	118	226
50	30	158	39	170	48	182	59	191	70	199	83	208	95	216	109	225	123	233
55	32	162	41	176	50	189	62	199	74	209	87	217	100	225	115	234	130	242
60	33	165	42	181	53	194	64	204	77	215	91	224	104	232	120	240	136	249
65	35	169	44	186	55	201	67	212	80	222	95	232	109	242	125	249	142	258
70	36	171	45	190	57	206	69	217	83	227	98	239	113	249	129	255	147	265
75	37	175	47	197	59	213	72	224	86	234	101	245	117	256	134	263	153	272
80	39	179	49	203	61	218	74	229	89	239	105	251	121	261	138	269	158	277

Diameter (DIA) in feet and flowrate (GPM) are based on CIT (Center for Irrigation Technology) testing and some comparisons. For 43° performance consult factory. In general, throw distance is reduced ~3% with each 3 drop in trajectory.

Pressure/nozzle combinations OUTSIDE of the shaded-in areas produce a more desirable stream.

FEATURES & BENEFITS:

- Long wear life with minimum maintenance.
- Precision manufactured for extra heavy-duty reliability.
- Slow, steady reverse action.
- Works well on sloping terrain.
- High performance at low pressure.

APPLICATIONS:

- Traveler System.
- Pivot End Gun.
- Permanent Set.
- Environmental Control System.
- Wastewater Application.

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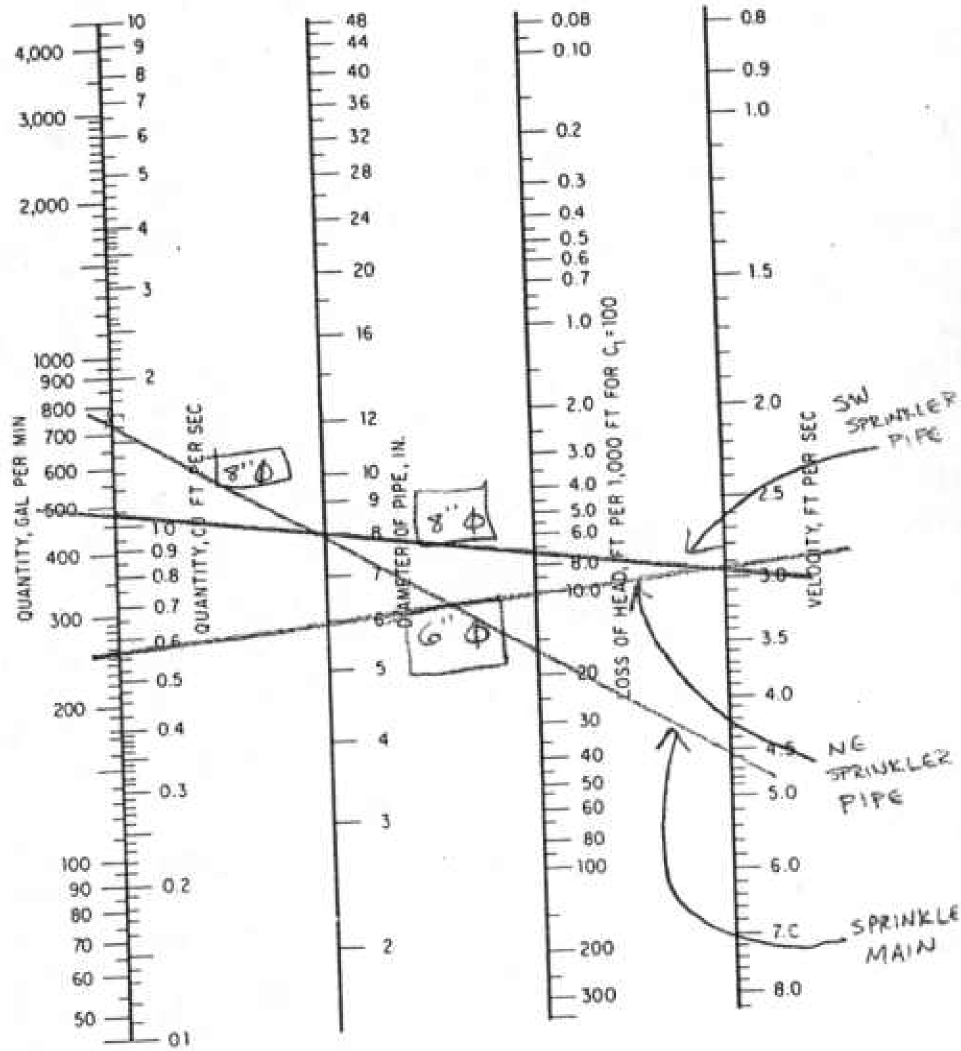
Appendix M: Hazen-Williams Nomograph

$(C = 100)$

For values of C other than 100, multiply the nomograph values for head loss by $\left(\frac{100}{C}\right)^{1.85}$



FLUIDS

S.O. No. ______

Subject: HMI PIPE CALCS.

Sheet No. 6 of 17

Drawing No. ______

Computed by TAB Checked By ______ Date 22 JAN 02

Baker

LOSSES

$$h_{L_{PIPE}} = 10.44 \cdot \frac{(L\,(ft))\,(Q\,(gpm))^{1.85}}{C^{1.85}\,(d_{inches})^{4.8655}}$$

$$h_{L_{PIPE_{SW}}} = 10.44 \cdot \frac{(2400' - 80')\,(480\ gpm)^{1.85}}{(140)^{1.85}\,(8'')^{4.8655}} = \boxed{9.55'}$$

$$h_{L_{PIPE_{NE}}} = 10.44\ \frac{(1240' - 80')\,(256\ gpm)^{1.85}}{(140)^{1.85}\,(6'')^{4.8655}} = \boxed{6.05'}$$

$$h_{L_{PIPE_{SM}}} = 10.44 \cdot \frac{(1635')\,(736\ gpm)^{1.85}}{(140)^{1.85}\,(8'')^{4.8655}} = \boxed{14.85'}$$

MINOR LOSSES

OBTAINED FROM "DRISCOPIPE: POLYETHYLENE PIPING SYSTEMS MANUAL" p. 20 TABLE 7

QUANTITY	FITTING	SIZE	EQ. PIPE LENGTH / FITTING	l_{eq}	
8" Φ SPRINKLER SW					
90° ELBOW	1	8"	30·D	20.0'	206.67' = $l_{eq_{SW}}$
RUNNING T	14	8"	20·D	186.67'	
6" Φ SPRINKLER NE					
90° ELBOW	1	6"	30·D	15.0'	85.0' = $l_{eq_{NE}}$
RUNNING T	7	6"	20·D	70.0'	
8" Φ SPRINKLER MAIN					
90° ELBOW	3	8"	30·D	60.0'	184.0' = $l_{eq_{M}}$
BRANCH T	1	8"	50·D	33.33'	
45° ELBOW	2	8"	18·D	24.0'	
CONV. SWING CHECK VALVE	1	8"	100·D	66.67'	

S.O. No. ______

Subject: HMI PIPING CALCULATIONS

Sheet No. 7 of 17

Drawing No. ______

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Baker

$$TDH = h_s + h_f + h_v + h_p$$

$$h_{f_s} = h_{f_{SM}} + (\text{THE GREATER OF } h_{f_{SW}} \text{ \& } h_{f_{NE}})$$

$$h_{f_{SM}} = h_{L_{PIPE_{SM}}} + h_{L_{leq_{SM}}}$$

$$h_{f_{SM}} = 14.85' + 10.44 \cdot \frac{(184.0')(736\text{gpm})^{1.85}}{(140)^{1.85}(8'')^{4.8655}} = \boxed{16.52'}$$

$$h_{f_{SW}} = h_{L_{PIPE_{SW}}} + h_{L_{leq_{SW}}}$$

$$h_{f_{SW}} = 9.55' + 10.44 \cdot \frac{(206.47')(480\text{ gpm})^{1.85}}{(140)^{1.85}(8'')^{4.8655}} = \boxed{10.40'}$$

$$h_{f_{NE}} = h_{L_{PIPE_{NE}}} + h_{L_{leq_{NE}}}$$

$$h_{f_{NE}} = 6.05' + 10.44 \cdot \frac{(85.0')(256\text{ gpm})^{1.85}}{(140)^{1.85}(6'')^{4.8655}} = \boxed{6.49'}$$

$$h_{f_s} = 16.52' + 10.40'$$

$$\boxed{h_{f_s} = 26.92'}$$

h_p & h_v

THE PRESSURE REQUIRED AT THE NOZZLE IS 55 psi ACCORDING TO THE MANUFACTURER IN ORDER TO PROVIDE A THROW DIAMETER OF 162'. ALTHOUGH THIS IS NOT ACTUALLY A HEAD LOSS DUE TO PRESSURE/VELOC (IT IS REALLY h_L DUE TO THE NOZZLE DIMENSIONS AND EXIT LOSSES, WHICH THE MANUFACTURER HAS ALREADY CALCULATED AND GIVEN TO US AS A PRESSURE THAT WE NEED TO PROVIDE), WE WILL SHOW IT IN OUR EQUATION AS SUCH.

$$\therefore h_v/h_p = \frac{55 \times 2.31}{1} = 127.05'$$ USING CONVERSION ON NEXT PAGE

8/17

SECTION I — HYDRAULIC FUNDAMENTALS

HYDRAULICS

The science of hydraulics is the study of the behavior of liquids at rest and in motion. This handbook concerns itself only with information and data necessary to aid in the solution of problems involving the flow of liquids: viscous liquids, volatile liquids, slurries and in fact almost any of the rapidly growing number of liquids that can now be successfully handled by modern pumping machinery.

In a liquid at rest, the absolute pressure existing at any point consists of the weight of the liquid above the point, expressed in psi, plus the absolute pressure in psi exerted on the surface (atmospheric pressure in an open vessel). This pressure is equal in all directions and exerts itself perpendicularly to any surfaces in contact with the liquid. Pressures in a liquid can be thought of as being caused by a column of the liquid which, due to its weight, would exert a pressure equal to the pressure at the point in question. This column of the liquid, whether real or imaginary, is called the static head and is usually expressed in feet of the liquid.

Pressure and head are, therefore, different ways of expressing the same value. In the vernacular of the industry, when the term "pressure" is used it generally refers to units in psi, whereas "head" refers to feet of the liquid being pumped. These values are mutually convertible, one to the other, as follows:

$$\frac{\text{psi} \times 2.31}{\text{sg.}} = \text{Head in feet.}$$

Convenient tables for making this conversion for water will be found in Section III, Table 13 of this Handbook.

Pressure or heads are most commonly measured by means of a pressure gauge. The gauge measures the pressure above atmospheric pressure. Therefore, absolute pressure (psia) = gauge pressure (psig) plus barometric pressure (14.7 psi at sea level).

Since in most pumping problems differential pressures are used, gauge pressures as read and corrected are used without first converting to absolute pressure.

S.O. No.

Subject: HMA PIPE CALCS.

Sheet No. 9 of 17

Drawing No.

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h_s

h_s = DISCHARGE ELEV − INTAKE ELEV + LOSSES FROM INTAKE TO WET WELL

DISCHARGE ELEV = 20.0'

INTAKE ELEV = 0'

LOSSES FROM INTAKE TO WET WELL

- INTAKE SCREEN
- MINOR LOSSES

$Q_{MAX_{INTAKE\ PIPE}} = Q_{SPRINKLER} + Q_{FILL}$

$= 800 \text{ gpm} + 1300 \text{ gpm}$

$Q_{MAX_{INTAKE\ PIPE}} = 2100 \text{ gpm}$

$$A_{INTAKE\ PIPE} = \frac{Q_{MAX}}{V_{INTAKE}}$$

MAX ALLOWABLE V FOR HDPE IS $6 \frac{ft}{sec}$

$$A_{INTAKE\ PIPE} = \frac{2100 \frac{gal}{min} \cdot \frac{1 \text{ min}}{60 \text{ sec}} \cdot \frac{0.1337 \text{ ft}^3}{gal}}{6 \frac{ft}{sec}} = .7799 \text{ ft}^2$$

$$d = 2 \cdot \sqrt{\frac{A}{\pi}} = 2 \cdot \sqrt{\frac{.7799 \text{ ft}^2}{\pi}} = .9965 \text{ ft} \cdot \frac{12''}{ft} = 11.96'' \Phi \sim 12'' \Phi$$

WE'LL USE A 14" Φ PIPE

$l_{INTAKE\ PIPE} = 100'$

MINOR LOSSES

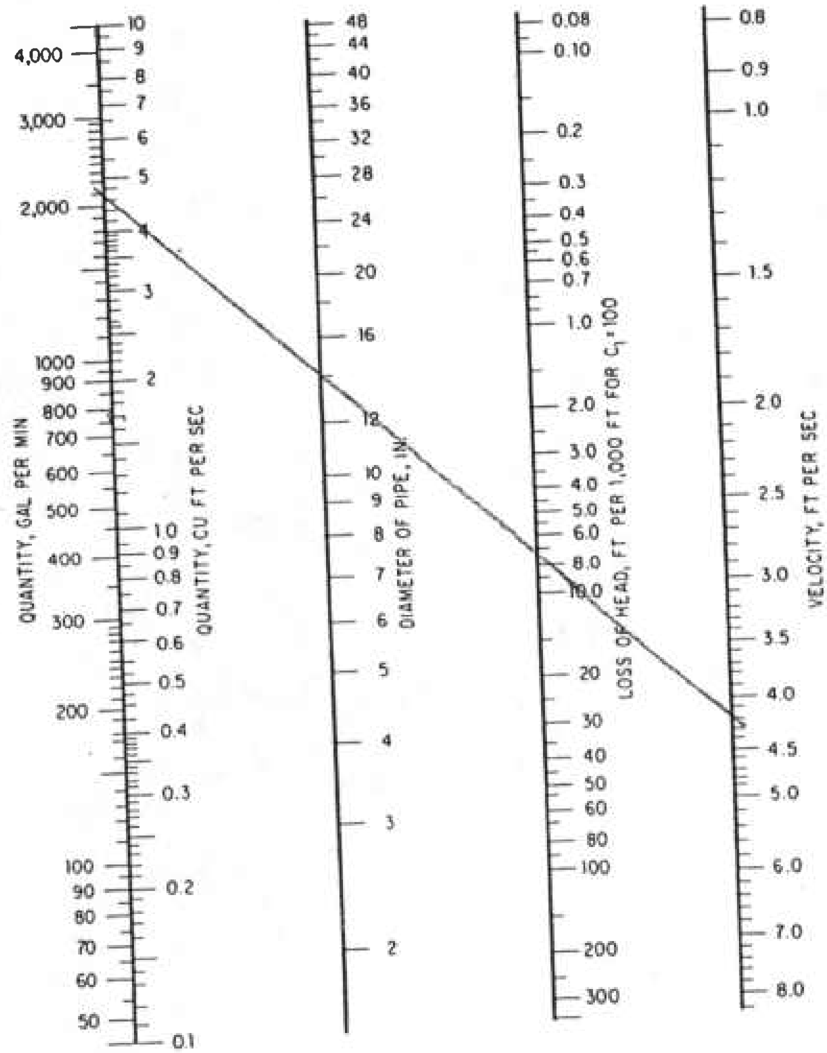
			EQU. PIPE LENGTH	L_{eq}
90° ELBOW	1	14"	30·D	35.0'

10/17

Appendix M: Hazen-Williams Nomograph

($C = 100$)

For values of C other than 100, multiply the nomograph values for head loss by $\left(\frac{100}{C}\right)^{1.85}$



S.O. No.

Subject: HMI PIPE CALCS.

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Drawing No.

Computed by TAB Checked By Date 25 JAN 02

$$h_{f_{INT}} = 10.44 \cdot \frac{(L(ft)) \cdot (Q(gpm))^{1.85}}{C^{1.85} \cdot (d(inches))^{4.8655}}$$

$$h_{f_{INTAKE}} = 10.44 \cdot \frac{(100' + 35') \cdot (2100gpm)^{1.85}}{(140)^{1.85} \cdot (14'')^{4.8655}}$$

$$h_{f_{INTAKE}} = \underline{.5601 ft}$$

INTAKE SCREEN LOSSES = $\underline{.75 \text{ ft}}$ BASED ON MANUFACTURER'S DATA (JOHNSON SCREENS, TOM WATSON 508.347.9200) 25 JAN 02 FOR A T-21 316 STEEL SCREEN W/ .1'' OPENINGS)

$$\therefore \quad h_{f_{INTAKE}} = .75' + .56' = 1.31'$$

$$h_s = 20.0' - 0.0' + 1.31'$$

$$\boxed{h_s = 21.31'}$$

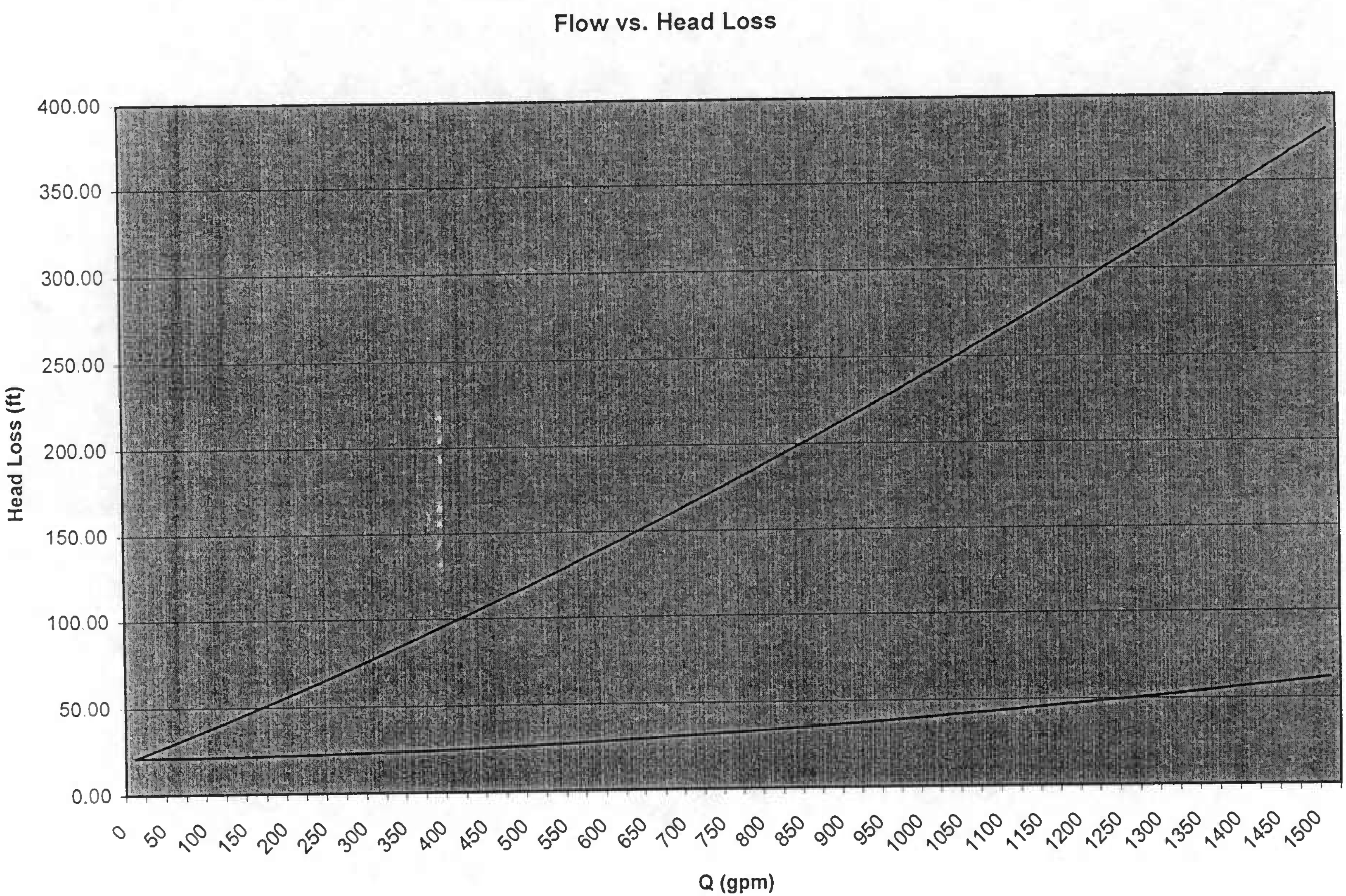
$$\therefore \quad TDH_s = h_s + h_f + h_v + h_p$$

$$TDH_{SPRINKLER} = 21.31' + 26.92' + 127.05' = \boxed{175.28'} \text{ @ } 736 \text{ gpm}$$

IF USING 800 gpm PUMP. $TDH_{SPRINKLER} = 140.40'$

Q (gpm)	hL (static)	Sprinkler hL (friction)			hL (pressure) (velocity)	Sprinkler TDH (ft)	Fill hL (friction)	Fill TDH (ft)
		Sprinkler Main	SW	NE				
0	21.31	0.00	0.00	0.00	0.00	21.31	0.00	21.31
25	21.31	0.03	0.02	0.01	4.30	25.66	0.02	21.33
50	21.31	0.11	0.07	0.04	8.60	30.10	0.07	21.38
75	21.31	0.24	0.15	0.10	12.91	34.61	0.16	21.47
100	21.31	0.41	0.26	0.16	17.21	39.19	0.27	21.58
125	21.31	0.62	0.39	0.24	21.51	43.83	0.40	21.71
150	21.31	0.87	0.55	0.34	25.81	48.54	0.57	21.88
175	21.31	1.16	0.73	0.46	30.12	53.31	0.75	22.06
200	21.31	1.48	0.93	0.58	34.42	58.15	0.97	22.28
225	21.31	1.84	1.16	0.73	38.72	63.04	1.20	22.51
250	21.31	2.24	1.41	0.88	43.02	67.99	1.46	22.77
275	21.31	2.67	1.68	1.05	47.33	72.99	1.74	23.05
300	21.31	3.14	1.98	1.23	51.63	78.06	2.04	23.35
325	21.31	3.64	2.29	1.43	55.93	83.18	2.37	23.68
350	21.31	4.18	2.63	1.64	60.23	88.35	2.72	24.03
375	21.31	4.74	2.99	1.87	64.54	93.58	3.09	24.40
400	21.31	5.35	3.37	2.10	68.84	98.86	3.48	24.79
425	21.31	5.98	3.77	2.35	73.14	104.20	3.89	25.20
450	21.31	6.65	4.19	2.61	77.44	109.59	4.33	25.64
475	21.31	7.35	4.63	2.89	81.75	115.03	4.78	26.09
500	21.31	8.08	5.09	3.18	86.05	120.52	5.26	26.57
525	21.31	8.84	5.57	3.48	90.35	126.07	5.76	27.07
550	21.31	9.64	6.07	3.79	94.65	131.67	6.28	27.59
575	21.31	10.46	6.59	4.11	98.95	137.32	6.81	28.12
600	21.31	11.32	7.13	4.45	103.26	143.02	7.37	28.68
625	21.31	12.21	7.69	4.80	107.56	148.76	7.95	29.26
650	21.31	13.13	8.27	5.16	111.86	154.56	8.55	29.86
675	21.31	14.07	8.87	5.54	116.16	160.41	9.17	30.48
700	21.31	15.05	9.48	5.92	120.47	166.31	9.80	31.11
725	21.31	16.06	10.12	6.32	124.77	172.26	10.46	31.77
750	21.31	17.10	10.77	6.73	129.07	178.26	11.14	32.45
775	21.31	18.17	11.45	7.15	133.37	184.30	11.84	33.15
800	21.31	19.27	12.14	7.58	137.68	190.40	12.55	33.86
825	21.31	20.40	12.85	8.02	141.98	196.54	13.29	34.60
850	21.31	21.56	13.58	8.48	146.28	202.73	14.04	35.35
875	21.31	22.75	14.33	8.95	150.58	208.97	14.81	36.12
900	21.31	23.96	15.10	9.43	154.89	215.26	15.61	36.92
925	21.31	25.21	15.88	9.92	159.19	221.59	16.42	37.73
950	21.31	26.49	16.68	10.42	163.49	227.97	17.25	38.56
975	21.31	27.79	17.50	10.93	167.79	234.40	18.10	39.41
1000	21.31	29.12	18.34	11.45	172.10	240.87	18.97	40.28
1025	21.31	30.48	19.20	11.99	176.40	247.39	19.85	41.16
1050	21.31	31.87	20.08	12.54	180.70	253.96	20.76	42.07
1075	21.31	33.29	20.97	13.09	185.00	260.57	21.68	42.99
1100	21.31	34.74	21.88	13.66	189.30	267.23	22.62	43.93
1125	21.31	36.21	22.81	14.24	193.61	273.94	23.58	44.89

1150	21.31	37.71	23.76	14.83	197.91	280.69	24.56	45.87
1175	21.31	39.24	24.72	15.44	202.21	287.49	25.56	46.87
1200	21.31	40.80	25.70	16.05	206.51	294.33	26.57	47.88
1225	21.31	42.39	26.70	16.67	210.82	301.22	27.61	48.92
1250	21.31	44.00	27.72	17.31	215.12	308.15	28.66	49.97
1275	21.31	45.65	28.75	17.95	219.42	315.13	29.73	51.04
1300	21.31	47.32	29.81	18.61	223.72	322.15	30.81	52.12
1325	21.31	49.01	30.87	19.28	228.03	329.22	31.92	53.23
1350	21.31	50.74	31.96	19.96	232.33	336.34	33.04	54.35
1375	21.31	52.49	33.06	20.65	236.63	343.49	34.18	55.49
1400	21.31	54.27	34.19	21.34	240.93	350.70	35.34	56.65
1425	21.31	56.08	35.32	22.06	245.24	357.94	36.52	57.83
1450	21.31	57.91	36.48	22.78	249.54	365.23	37.71	59.02
1475	21.31	59.77	37.65	23.51	253.84	372.57	38.93	60.24
1500	21.31	61.66	38.84	24.25	258.14	379.95	40.15	61.46


Flow vs. Head Loss
Head Loss (ft)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500
Q (gpm)

14/17

S.O. No. ______

Subject: HMI PIPING CALCS. – FILL SYSTEM

Sheet No. 15 of 17

Drawing No. ______

Computed by TAB Checked By ______ Date 29 JAN 02

Baker

TDH_{FILL}

$l_{FILL\ PIPE} = 3270$ ft

$Q_{F_{MAX}} = 1,245$ gpm

CALCULATE PIPE DIAMETER BASED ON MAX. SUGGESTED VELOCITY FOR HDPE PIPES OF 6 ft/sec.

$$A_F = \frac{Q_{F_{MAX}}}{V} = \frac{1245\ \frac{gal}{min} \cdot \frac{0.1337\ ft^3}{gal}}{6\ \frac{ft}{sec} \cdot \frac{60\ sec}{min}} = .4624\ ft^2$$

$$d_F = 2 \cdot \sqrt{\frac{A}{\pi}} = 2 \cdot \sqrt{\frac{.4624\ ft^2}{\pi}} = .7673' \cdot \frac{12''}{ft}$$

$$d_F = 9.21''$$

$\therefore$ WE'LL USE A 12" FILL PIPE

USING THE HAZEN-WILLIAMS NOMOGRAPH ON THE NEXT PAGE, IT ALLOWS A 10" Φ PIPE AND SHOWS @ A V = 5.0 ft/sec

$$h_{f_F} = \frac{15.0\ ft}{1000\ ft} \cdot 3270\ ft \cdot \left(\frac{100}{140}\right)^{1.85} \approx 26.32'$$ USING NOMOGRAPH

$$TDH_F = h_s + h_f + h_v + h_p$$

ASSUME THAT INTAKE POND AND FILL AREA ARE AT REST AND OPEN TO THE ATMOSPHERE, h_v & $h_p = 0$

$$\therefore TDH_F = h_{s_F} + h_{f_F}$$

$h_{s_F} = h_{s_S}$ BOTH THE SPRINKLER AND FILL SYSTEM ARE UTILIZING THE SAME INTAKE SYSTEM AND PIPING UP TO THE WET WELL. THEY ALSO WILL BE DISCHARGING AT THE SAME ELEVATION (20.0' MLW).

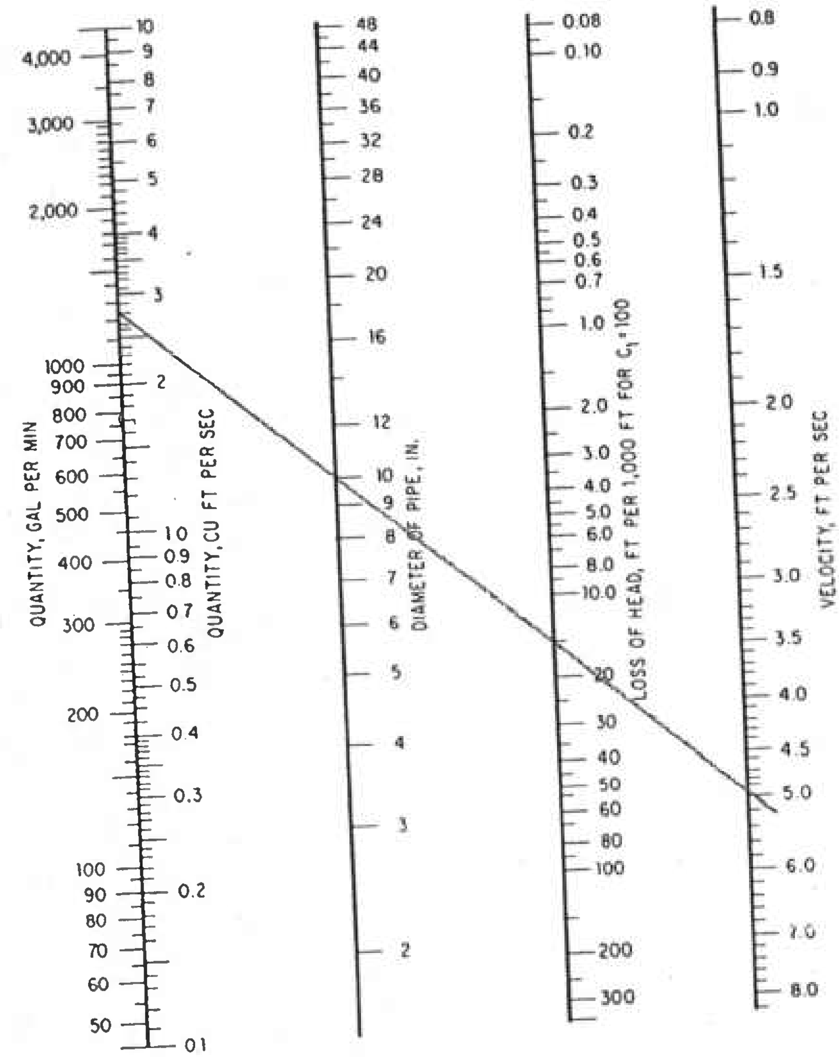
$$\therefore h_{s_F} = h_{s_S} = \boxed{21.31'}$$

16/17

Appendix M: Hazen-Williams Nomograph

($C = 100$)

For values of C other than 100, multiply the nomograph values for head loss by $\left(\frac{100}{C}\right)^{1.85}$



S.O. No. ______

Subject: HMI PIPING CALCS - FILL SYSTEM

Sheet No. 17 of 17

Drawing No. ______

Computed by TAB Checked By ______ Date 29 JAN 02

Baker

h_f = MINOR LOSSES + PIPE FRICTION LOSS

I'LL CALCULATE BY TURNING THE MINOR LOSSES INTO EQUIVALENT LENGTHS, AND THEN ADD TO THE ACTUAL PIPE AND PLUG INTO THE HAZEN-WILLIAMS EQUATION.

BASED ON "DRISCOPIPE: POLYETHYLENE PIPING SYSTEMS MANUAL" p. 20 TABLE 7

FITTING	QUANTITY	SIZE	EQ. PIPE LENGTH / FITTING	l_{eq}
90° ELBOW	5	10"	30·D	125'
45° ELBOW	2	10"	18·D	30'
CONV. SWING CHECK VALVE	1	10"	100·D	83.33'

TOT l_{eq} = 238.33'

$$h_{f_F} = 10.44 \cdot \frac{(3270' + 238.33') \cdot (1245\ \text{gpm})^{1.85}}{(140)^{1.85} \cdot (10")^{4.8655}}$$

$$\boxed{h_{f_F} = 28.44'}$$

$$TDH_F = h_{s_F} + h_{f_F} = 21.31' + 28.44' = \boxed{49.75'}$$

S.O. No. 22939 - 014 - 0000   T.O.# 00220

Subject: HMI PIPE CALCS II

Sheet No. 1 of 6

Drawing No.

Computed by TAB   Checked By   Date 12 MAR 02

Baker

AFTER SPEAKING W/ GENE BROWN, MANUFACTURER OF BIG GUN SPRINKLERS, NELSON IRRIGATION, HE RECOMMENDED UTILIZING AN SR 75, 24° TRAJECTORY, THEY ONLY MAKE THIS IN BRASS, NOT STAINLESS STEEL. AFTER CONSULTING WITH OUR CORROSION SUBCONSULTANT, IT WAS DETERMINED THAT BRASS WOULD BE FINE WHEN COMPARED WITH TRIPLE THE COST FOR THE STAINLESS STEEL HEADS. ALSO, THE MANUFACTURER RECOMMENDED MAINTAINING 70 PSI AND UTILIZE 100' SPACING WITH THE 0.4" HEAD TO ENSURE ADEQUATE COVERAGE.

MUDFLAT HYDRATION SYSTEM (MHS)

$L_{MHS\ PIPE} = 3640'$ SHORTEN TO 3600'

∴ EXPECT $\frac{24}{37}$ OF FLOW TO SW

EXPECT $\frac{13}{37}$ OF FLOW TO NE

REQUIRED FLOW TO SPRINKLER

$$Q_{REQ} = \frac{36\ gpm}{HEAD} \cdot 37\ \text{HEADS} = 1332\ gpm$$

$$Q_{SW} = \frac{24}{37} \cdot 1332\ gpm = 864\ gpm$$

$$Q_{NE} = \frac{13}{37} \cdot 1332\ gpm = 468\ gpm$$

KEEPING $V < 6$ ft/sec (MAX SUGGESTED FOR HDPE)

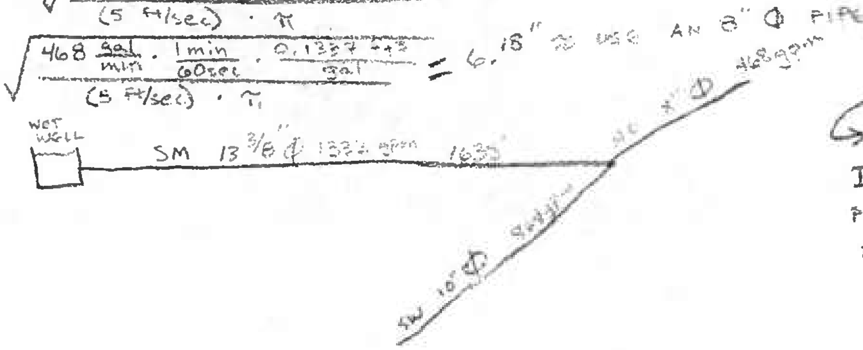
$$d_{SM} = 2 \cdot \sqrt{\frac{Q/V}{\pi}} = 2 \cdot \sqrt{\frac{1332 \frac{gal}{min} \cdot \frac{1\ min}{60\ sec} \cdot \frac{0.1337\ ft^3}{gal}}{(5\ ft/sec) \cdot \pi}} = 10.43'' \approx \text{USE A } 13\tfrac{3}{8}''\ \Phi \text{ PIPE}$$

$$d_{SW} = 2 \cdot \sqrt{\frac{864 \frac{gal}{min} \cdot \frac{1\ min}{60\ sec} \cdot \frac{0.1337\ ft^3}{gal}}{(5\ ft/sec) \cdot \pi}} = 8.40'' \approx \text{USE A } 10''\ \Phi \text{ PIPE}$$

$$d_{NE} = 2 \cdot \sqrt{\frac{468 \frac{gal}{min} \cdot \frac{1\ min}{60 sec} \cdot \frac{0.1337\ ft^3}{gal}}{(5\ ft/sec) \cdot \pi}} = 6.18'' \approx \text{USE AN } 8''\ \Phi \text{ PIPE}$$

THESE ARE BASED ON I.D. & 160 psi D.R. 11 PIPE PE 3408 PLEXCO PIPE

∴



2/6

75BGN 5/01

Innovation in Irrigation™ NELSON

BIG GUN® PERFORMANCE —

SR75 (Heavy Duty pictured)

Part Circle: SR75
Trajectories: 12°, 18°, 21°, 24°, 27°, 43°
Connection Options Include:
- 1 1/2" FNPT or FBSP
- 2" FNPT or FBSP
- 2 1/2" FNPT
- ANSI/DIN Flange (bolt on), Nelson Flange, Metric Flange

Lower Bearing Options:
- Heavy Duty

75 TAPER RING NOZZLE — **TR75** — 24° TRAJECTORY

150 $1400 $4809

TR75 Taper Rings are ordered individually.
Specify size when ordering

	0.4"		0.45"		0.5"		0.55"		0.6"		0.65"		0.7"		0.75"		0.8"	
PSI	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.	GPM	DIA.FT.
25							42	143	50	152	59	158	69	164	80	171	91	178
30					37	155	45	155	55	162	64	169	75	178	87	183	99	188
35			32	151	40	161	49	169	59	175	69	187	81	192	93	198	106	204
40	27	147	35	157	43	168	52	177	63	186	74	194	87	200	98	208	112	217
45	29	152	37	164	46	176	56	185	67	194	79	202	91	209	104	218	118	226
50	30	158	39	170	48	182	59	191	70	199	83	208	95	216	109	225	123	233
55	32	162	41	176	50	189	62	199	74	209	87	217	100	225	115	234	130	242
60	33	165	42	181	53	194	64	204	77	215	91	224	104	232	120	240	136	249
65	35	169	44	186	55	201	67	212	80	222	95	232	109	242	125	249	142	258
70	36	171	45	190	57	206	69	217	83	227	98	239	113	249	129	255	147	265
75	37	175	47	197	59	213	72	224	86	234	101	245	117	256	134	263	153	272
80	39	179	49	203	61	218	74	229	89	239	105	251	121	261	138	269	158	277

100' SPACING

Diameter (DIA) in feet and flowrate (GPM) are based on CIT (Center for Irrigation Technology) testing and some comparisons. For 43° performance consult factory. In general, throw distance is reduced ~3% with each 3 drop in trajectory.

Pressure/nozzle combinations OUTSIDE of the shaded-in areas produce a more desirable stream.

- Long wear life with minimum maintenance.
- Precision manufactured for extra heavy-duty reliability.
- Slow, steady reverse action.
- Works well on sloping terrain.
- High performance at low pressure.

- Traveler System.
- Pivot End Gun.
- Permanent Set.
- Environmental Control System.
- Wastewater Application.

WARRANTY AND DISCLAIMER

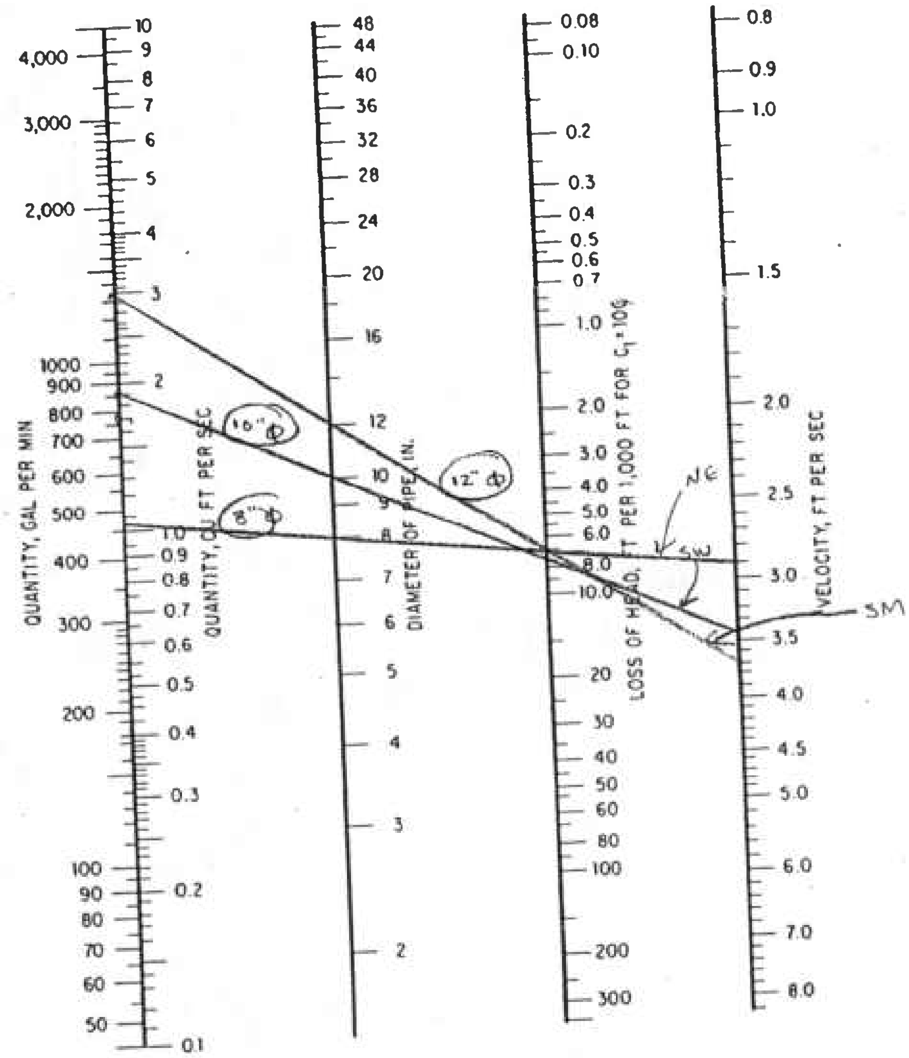
Nelson Big Gun® Sprinklers are warranted for one year from date of original sale to be free of defective materials and workmanship when used within the working specifications for which the products were designed and under normal use and service. The manufacturer assumes no responsibility for installation, removal or unauthorized repair of defective parts. The manufacturer's liability under this warranty is limited solely to replacement or repair of defective parts and the manufacturer will not be liable for any crop or other consequential damages resulting from defects or breach of warranty. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSES AND OF ALL OTHER OBLIGATIONS OR LIABILITIES OF MANUFACTURER. No agent, employee or representative of the manufacturer has authority to waive, alter or add to the provisions of this warranty, nor to make any representations or warranty not contained herein.

3/6

Appendix M: Hazen-Williams Nomograph

$(C = 100)$

For values of C other than 100, multiply the nomograph values for head loss by $\left(\frac{100}{C}\right)^{1.85}$



S.O. No. 22939-014-0000 T.O.# 00220

Subject: HMI PUMP CALCS II

Sheet No. 4 of 6

Drawing No.

Computed by TAB Checked By Date 12 MAR 02

Baker

LOSSES

$$h_{L\,PIPE} = 10.44 \cdot \frac{L(ft)\,(Q(gpm))^{1.85}}{C^{1.85}\,(d_{inches})^{4.8655}}$$ ASSUME C=140 FOR HDPE

$$h_{L_{SM}} = 10.44 \cdot \frac{1635' \cdot (1332\text{ gpm})^{1.85}}{(140)^{1.85} \cdot (12'')^{4.8655}} = \boxed{6.19'}$$

$$h_{L\,PIPE_{SW}} = 10.44 \cdot \frac{2400' \cdot (864\text{ gpm})^{1.85}}{(140)^{1.85} \cdot (10'')^{4.8655}} = \boxed{9.90'} + (.09') \cdot 24 = \boxed{12.06'}$$

$$h_{L\,PIPE_{NE}} = 10.44 \cdot \frac{1200' \cdot (468\text{ gpm})^{1.85}}{(140)^{1.85} \cdot (8'')^{4.8655}} = \boxed{4.72'} + (.09') \cdot 13 = \boxed{5.89'}$$

$$h_{L\,RISER\,PIPE} = 10.44 \cdot \frac{3' \cdot (36\text{ gpm})^{1.85}}{(140)^{1.85}\,(2'')^{4.8655}} = \boxed{.09'}$$

MINOR LOSSES

FITTING	QUANTITY	SIZE	EQ. PIPE LENGTH / FITTING	l_{EQ}	
12" I.D. SPRINKLER MAIN					
90° ELBOW	2	12"	30·D	60.0'	$l_{eq_{SM}}$ = 261.0'
45° ELBOW	2	12"	18·D	36.0'	
BRANCH T	1	12"	50·D	50.0'	
CONV. SWING CHECK VALVE	1	12"	100·D	100.0'	
CONV. WEDGE GATE VALVE	1	12"	15·D	15.0'	
10" I.D. SPRINKLER S.W.					
90° ELBOW	1	10"	30·D	25.0'	$l_{eq_{SW}}$ = 101.7'
RUNNING T	23	2"	20·D	76.7'	
8" I.D. SPRINKLER NE					
90° ELBOW	1	8"	30·D	20.0'	$l_{eq_{NE}}$ = 60.0'
RUNNING T	12	2"	20·D	40.0'	

TDH

$$TDH = h_s + h_f + h_v + h_p$$

$$h_{f_{MHS}} = h_{f_{SM}} + (\text{THE GREATER OF } h_{f_{SW}} \text{ \& } h_{f_{NE}})$$

$$h_{f_{SM}} = h_{L\,PIPE\,SM} + h_{l_{eq\,SM}}$$

$$h_{f_{SM}} = 6.19' + 10.44 \cdot \frac{(261.0') \cdot (1332\text{ gpm})^{1.85}}{(140)^{1.85} \cdot (12'')^{4.8655}} = \boxed{7.18'}$$

S.O. No. 22939-014-0000 T.O.# 00220

Subject: HMI PUMP CALCS, II

Sheet No. 5 of 6

Drawing No.

Computed by TAB Checked By Date 12 MAR 02

Baker

$$h_{f_{SW}} = 12.06' + 10.44 \cdot \frac{(101.7') \cdot (864\ gpm)^{1.85}}{(140)^{1.85} \cdot (10'')^{4.8655}} = \boxed{12.48'}$$

$$h_{f_{DE}} = 5.89' + 10.44 \cdot \frac{(60.0') \cdot (468\ gpm)^{1.85}}{(140)^{1.85} \cdot (8'')^{4.8655}} = \boxed{6.13'}$$

$$h_{f_S} = 7.18' + 12.48' = \boxed{19.66'}$$

FROM PREVIOUS CALCS. $h_v + h_p = \frac{70 \cdot 2.31}{1} = 161.7'$

$$Q_{INTAKE} = Q_{SPRINKLED} + Q_{FILL}$$
$$= 1400\ gpm + 1300\ gpm$$
$$= 2700\ gpm$$

$$A_{INTAKE} = \frac{Q}{V}$$

MAX ALLOWABLE V FOR HDPE IS 6 ft/sec

$$A_{INTAKE} = \frac{2700 \frac{gal}{min} \cdot \frac{1\ min}{60\ sec} \cdot \frac{0.1337\ ft^3}{gal}}{6\ ft/sec} = 1.0028\ ft^2$$

$$d = 2 \cdot \sqrt{\frac{A}{\pi}} = 2 \cdot \sqrt{\frac{1.0028\ ft^2}{\pi}} = 1.1299\ ft \cdot \frac{12''}{ft} = 13.56'' \approx 14''\ \phi$$

$$l_{INTAKE} = 110'$$

MINOR LOSSES

			EQ PIPE LENGTH	l_{eq}
90° ELBOW	1	14"	30 · D	35.0'

$$h_{f_{INTAKE}} = 10.44 \cdot \frac{(110' + 35') \cdot (2700\ gpm)}{(140)^{1.85} \cdot (14'')^{4.8655}} = 0.96'$$

INTAKE SCREEN LOSSES = .75'

$$h_{f_{INTAKE}} = .75' + .96' = 1.71'$$

$$h_s = 23' + 1.71' = \boxed{24.71'}$$

S.O. No. 22939-014-0000 T.O.# 00220

Subject: HMI PUMP CALCS. II

Sheet No. 6 of 6

Drawing No.

Computed by TAB Checked By Date 12 MAR 02

Baker

$$TDH_s = h_{s_s} + h_{f_s} + h_{v_s} + h_{p_s}$$

$$TDH_s = 24.71' + 19.66' + 161.7' = 206.07' \text{ @ } 1332 \text{ gpm}$$

S.O. No. 22939-014-0000

Subject: PIPE CALCS. III

Sheet No. 1 of 1

Drawing No.

Computed by MB Checked By Date 9 APR 01

Baker

SINCE $13\frac{3}{8}$" ϕ VALVES ARE NOT READILY AVAILABLE, THESE CALCULATIONS ARE BEING PERFORMED TO ENSURE THAT A 14" ϕ PIPE FOR THE MHS WILL WORK.

REQUIRED FLOW TO SPRINKLER = Q_{REQ} = 1332 gpm (FROM p. 1 OF PIPE CALCS. II)

LOSSES

$$h_{L_{MHS\ MAIN}} = 10.44 \cdot \frac{1526' \,(1332\ gpm)^{1.85}}{(140)^{1.85}\,(14")^{4.8655}} = 2.73'$$

FROM p. 4 OF HMI PUMP CALCS. II

$$h_{L_{SW}} = 12.06'$$

$$h_{L_{NE}} = 5.89'$$

MINOR LOSSES

FITTING	QUANTITY	SIZE	EQ. PIPE LENGTH / FITTING	l_{eq}	
14" ϕ MHS MAIN					
90° ELBOW	2	14"	30·D	70.0'	$l_{eq_{MHS\ MAIN}}$ = 388.6'
45° ELBOW	6	14"	18·D	126.0'	
BRANCH T	1	14"	50·D	58.4'	
CONV. SWING CHECK VALVE	1	14"	100·D	116.7'	
CONV. WEDGE GATE VALVE	1	14"	15·D	17.5'	
10" ϕ SPRINKLER SW				101.7'	FROM p.4 HMI PUMP CALCS. II
8" ϕ SPRINKLER NE				60.0'	

$$h_{L_{MHS\ MAIN\ MINOR}} = 10.44 \cdot \frac{388.6' \cdot (1332\ gpm)^{1.85}}{(140)^{1.85}\,(14")^{4.8655}} = 0.70'$$

$$h_{L_{MHS\ MAIN}} = 2.73' + 0.70' = 3.43'$$

$$h_{L_{MHS}} = 3.43' + 12.48' = \boxed{15.91' = h_{f_{MHS}}}$$

$\boxed{h_v + h_p = 161.7'}$

$\boxed{h_s = 24.71'}$

FROM p. 5 OF HMI PUMP CALCS. II

$$TDH_{MHS} = h_s + h_f + h_v + h_p = 24.71' + 15.91' + 161.7' = \boxed{202.32' < 207'}$$

∴ OK WITH CURRENT PUMP

APPENDIX E

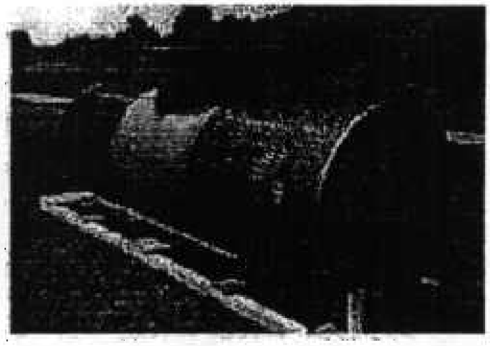
INFORMATION AND NOMOGRAPHS FOR FILTER SCREENS

HENDRICK SCREEN

Water Intake/Fish Diversion

Home
Company Info
Screen Types
Water Intake/Fish Diversion
Food & Beverage
Petrochemical
Pulp & Paper
Waste Water
Mining & Aggregate
Architectural
Sieve Bends
Quotes & Tech Data

Water Intake Screens / Fish Diversion Screens



Hendrick Screen has 30 years of experience and technical expertise in the production of stainless steel screens.

We are a leading producer of passive water intake screens used for the withdrawal of large volumes of water from streams, lakes and reservoirs.

Hendrick fish diversion screens are used in dam and river systems throughout North America to protect fish from hydroelectric turbines. Our screens comply with NMFS standards and they are specified by the U.S. Department of Fish and Wildlife dept., Corp of Engineers and many State Departments of Fish and Wildlife Depts. for the protection of fish.

What Is Passive Screening?

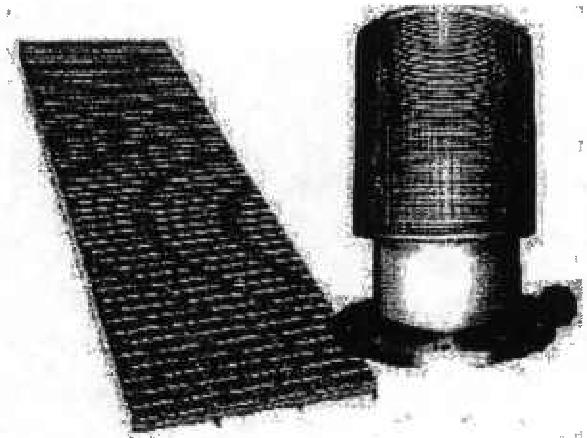
Passive screening admits water through the intake point at a low, uniform velocity. Water passes through the intake screen slots while aquatic life and debris remain in the water source. The intake screens have no moving parts, therefore the term "passive screening". They can be placed away from shore for better water quality and distant from high concentrations of debris and marine life.

Advantages Of Passive Screening

Passive water intake screens offer these advantages:

- Reliable water delivery
- Lower screen system costs
- Simpler intake and pump station design
- Lower total project costs
- Lower maintenance costs (No moving parts, no trash screens to clean, no on-land debris to handle, and no drive mechanisms to break down.)
- Small fouling material stays out of the pumping system
- Environmentally friendly to fish and other aquatic life

Keeping A Passive Intake Screen Clean



Sitting a water intake screen at the proper depth, distance from the shoreline, and proper distance from each other is a crucial step in avoiding clogging debris. Proper screen design is another. A Hendrick water intake screen minimizes plugging problems with built-in maximum open area so water enters the system at a low velocity. Potentially plugging materials are not held against the screen surface. Smaller fouling material is kept out of the pumping system by using narrow, uniform slot openings with very close tolerances.

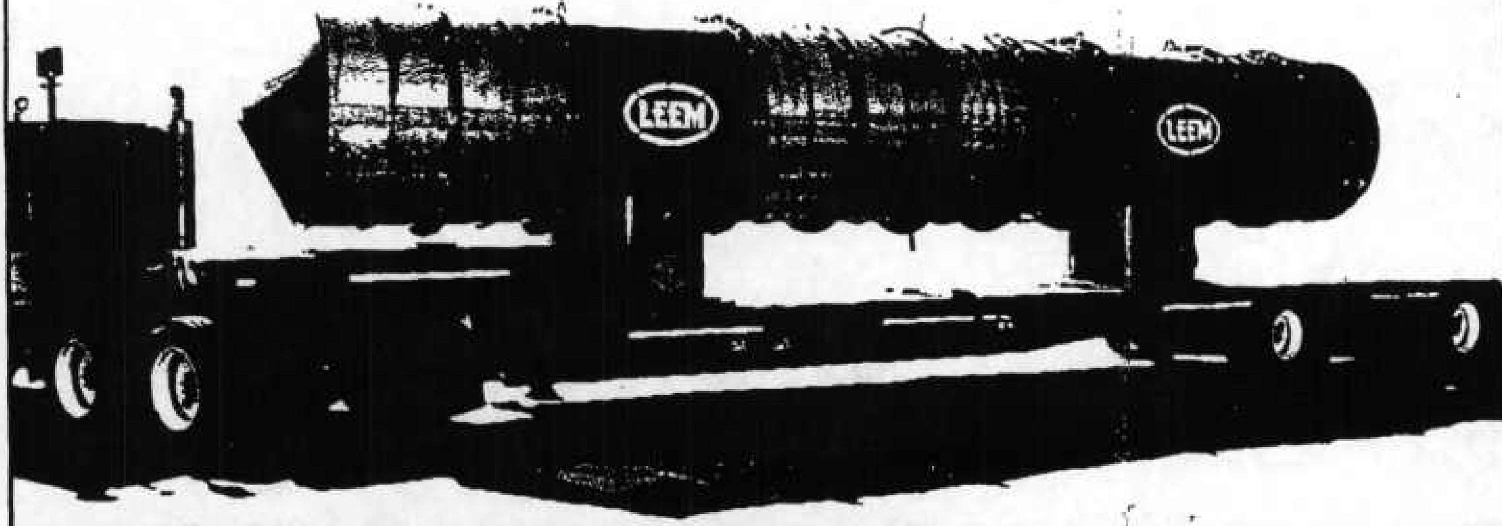
In high-debris environments, debris removal is achieved with the installation of a Hendrick airburst backwash system. Debris is carried up and away from the screen surface with a rapid release of air through pipes designed into the intake screen system.

Our water intake screens cause virtually no head loss while allowing fresh aerated water to pass through.

Visit our Quote and Tech Data section for more information.

2 of 2
Q-9303

..ER INTAKE SCREENS MANUFACTURED WITH CLOG-RESISTANT WEDGE-FLOW™



LEEM Filtration Products now manufactures high-quality Water Intake Screens, made with sturdy, clog-resistant Wedge-Flow custom designed and engineered to your specific application.

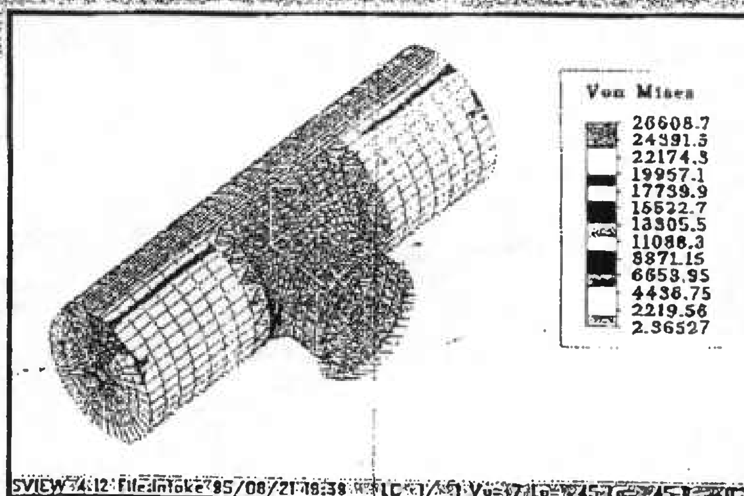
Our intake screens are made with Wedge-Flow™, LEEM's own brand of industrial grade wedge-wire. Wedge-Flow™ is specially constructed to resist clogging, while maximizing open area and ensuring required particle retention through precise slot sizes.

Our screens are designed to provide uniform low velocity throughout the entire screen surface, which all but eliminates screen blockage and plugging. By specifying a low through-slot velocity, leaves, algae, and aquatic life continue on their way, without being drawn into your process stream or covering-up the cuter surface of the intake screen.

LEEM WEDGE FLOW

LEEM's Intake Screens can be manufactured with a variety of stainless steels and other alloys depending on the working environment. Other options include an Air Sparging System which forces accumulated debris away from the screen, and a Chemical Feed Line that can add whatever biofouling chemicals you may require into the intake stream.

Our Engineers utilize Finite Element Analysis in order to design an Intake Screen which meets your exact process requirements. With FEA we can re-create the unique working environment of your intake system, which means that the screens we manufacture will conform to your specific hydrostatic collapse pressures. It also assures uniform velocity across the entire screen.



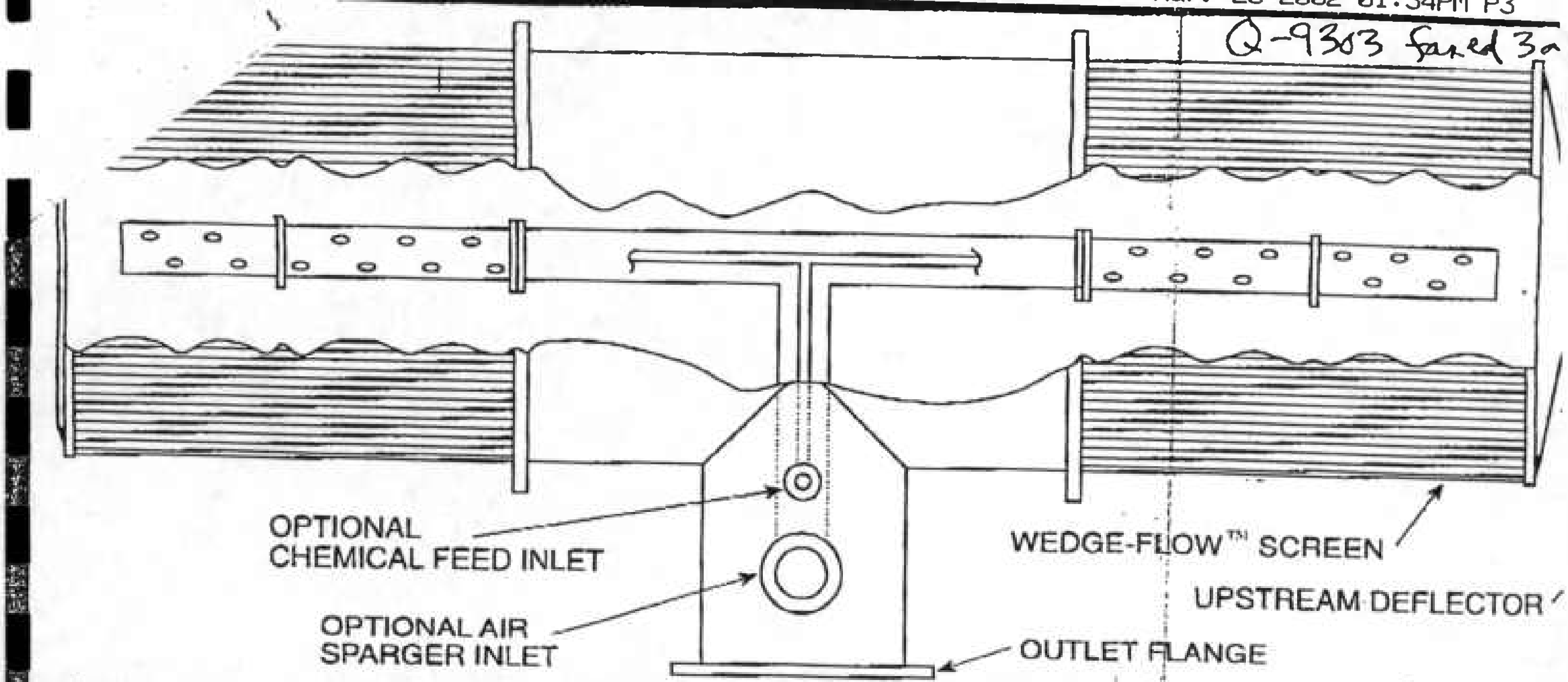
An example of Finite Element Analysis for an Intake Screen

At LEEM we not only design filters- we design solutions. We pride ourselves on our craftsmanship and quick response time. Our staff of experienced, innovative engineers excel in custom designs based on our customers' individual needs. Call us or fax us your specifications or drawings for a prompt quote.

LEEM

LEEM Filtration Products, Inc.
25 Arrow Road
Ramsey, NJ 07446
(201) 236-4833 FAX (201) 236-2004

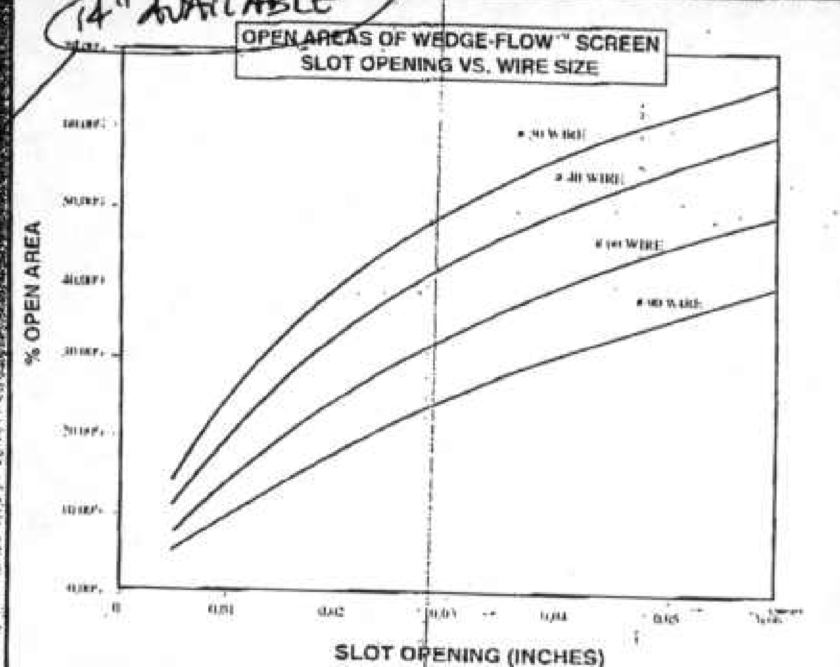
Q-9303 faxed 3a



STANDARD SIZE INTAKE SCREENS

Screen Area-inches sq.	Model #	Screen Diameter-inches	Overall Length-inches	Outlet Size-inches
1,000	WI-13	13	41	10
1,600	WI-17	17	50	12
2,000	WI-19	19	55	14
2,800	WI-21	21	65	16
3,700	WI-24	24	74	18
4,700	WI-26	26	85	20
5,500	WI-28	28	95	24
6,800	WI-32	32	101	24
8,000	WI-36	36	110	30
13,000	WI-42	42	140	30
17,000	WI-48	48	160	36
22,000	WI-54	54	180	36
27,000	WI-60	60	200	42
33,000	WI-66	66	220	48
40,500	WI-72	72	240	48
45,000	WI-78	78	250	54
53,000	WI-84	84	275	60
Over 53,000	Please call for calculation			

14" AVAILABLE



SIZING AN INTAKE SCREEN

1. Calculate the required open screen area:

$$\text{open screen area} = \frac{\text{GPM}}{1.558}$$ Based on a slot velocity of .5 FPS

2. Calculate the percent of open area:

$$\text{\% of open area} = \frac{\text{slot size}}{\text{slot size} + .09} \times 100$$

3. Calculate the total screen area required:

$$\text{total screen area} = \frac{\text{open screen area}}{\text{\% of open area}}$$

4. Look at the standard size screen chart and find the smallest screen which has a total screen area larger than the one calculated. This is the screen that matches your specs.

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LEEM WEDGE-FLOW